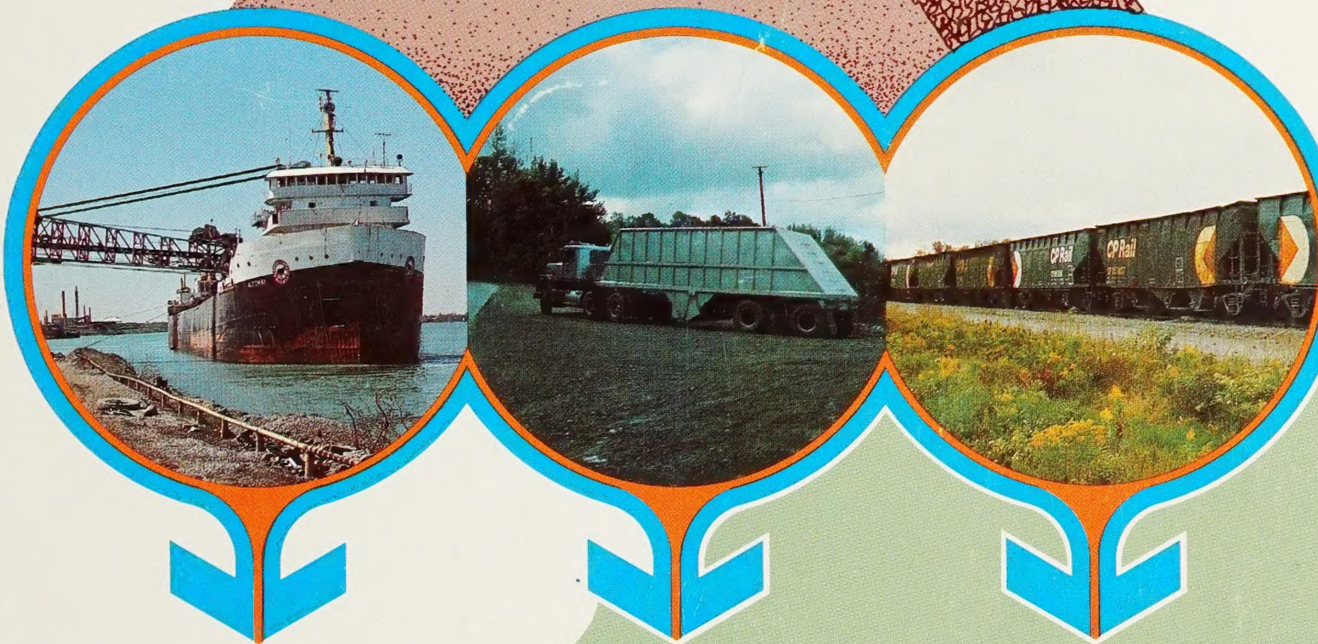
mineral aggregate transportation study



FINAL
REPORT

INDUSTRIAL MINERAL
BACKGROUND PAPER 1

prepared for:

Ministry of
Natural
Resources
Ontario

by: **PEAT MARWICK & PARTNERS**
M. M. DILLON LIMITED

Industrial Mineral Background Paper 1

Mineral Aggregate Transportation Study

FINAL REPORT

Prepared by
PEAT, MARWICK AND PARTNERS
and
M.M. DILLON LIMITED

December 1980

Ministry of Natural Resources
Ontario

Hon. James A. C. Auld
Minister

Dr. J. K. Reynolds
Deputy Minister

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Mineral Aggregate Transportation Study

Preface

The objective of the Ministry of Natural Resources is to ensure that aggregate resources are available for the future needs of all Ontarians. It must be recognized that aggregate deposits are a finite resource distributed unevenly throughout the Province based on events from glacial and pre-glacial times. The result is that aggregate resources are concentrated in communities such as Uxbridge, Caledon and Halton Hills where today there is a high level of extraction and in such areas as the County of Grey where future extraction activities may converge.

This publication represents the culmination of two years of Ministry funded research undertaken by consultants. I commissioned this research to investigate more remote, alternate sources of aggregate (such as in Grey) as possible future sources of supply to meet the projected demands in southern Ontario.

Transportation costs frequently form the major portion of the delivery price of aggregate originating from existing relatively close-to-the-market sources. It is important that the Government and the people of Ontario understand fully, both the financial and environmental implications of such a shift in supply sources.

In summary, the study indicates that, while Grey County contains one of the largest remaining reserves of sand and gravel in Southern Ontario, transportation of this material today is not economically feasible or environmentally desirable if the material is moved by either rail or road. Water haulage in combination with other modes of transport is even more unattractive from Grey County.

I am pleased to note the supplementary benefit of this study that the data produced can be used to analyze other transportation problems and can be applied to other bulk commodities. The study provides basic cost factors and data for the analysis of rail, water, and truck transportation of bulk commodities which should prove useful in a wide range of studies.

By the provision of this information to the public and to other arms of Government, I sincerely hope that we can all be better informed and hence more effective in achieving the best possible of all futures for Ontario.

James Auld

Hon. James A.C. Auld
Minister of Natural Resources

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Mineral Aggregate Transportation Study

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October 22, 1980

Dr. T.P. Mohide
Director, Mineral Resources Branch
Ministry of Natural Resources
Whitney Block
Queen's Park
Toronto, Ontario

Dear Sir:

Mineral Aggregate Transportation Study

We are pleased to submit our report of the Mineral Aggregate Transportation Study. This study has been one of a series of research projects carried out by the Ontario Ministry of Natural Resources with the objectives of achieving the most effective management of Ontario's mineral aggregate resources and ensuring a continuing security of supply.

The study investigated several options for attaining these objectives in terms of costs, quality of service and environmental impacts.

The results of the study are presented at three levels:

- The Summary highlights the major findings and conclusions of the study.
- The Final Report describes the methods and results of the study in more detail.
- The Technical Appendix contains the background data and detailed descriptions of the various study tasks and is available to those who are interested in specific details or further research on the subject.

We wish to thank the members of the Advisory Committee, the staff of the Ministry of Natural Resources and of several other Ontario ministries, the municipalities, the carriers, industry associations and all the individuals who made valuable contributions to the study by offering advice, information and cooperation.

Yours very truly,

M.M. DILLON LIMITED

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The Consultants wish to acknowledge the valuable help provided by the members of the Advisory Committee and by many organizations and individuals. Whereas the data and conclusions contained in this report were developed by the Consultants the advice of those who contributed to the Study assisted greatly in the completion of the project. The following is only a partial list of those who provided assistance:

The Aggregate Producers' Association of Ontario and producers who responded to the survey

The transportation carriers

The staff of provincial Ministries

The staff of municipal government offices

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EXHIBITS

EXECUTIVE SUMMARY

The Ontario Ministry of Natural Resources commissioned the Mineral Aggregate Transportation Study to examine the feasibility of supplying mineral aggregates to major urban centres from remote sources.

Toronto, London, Windsor and Sarnia were chosen as representative urban areas for the study. More than one third of the total mineral aggregate volume produced in Ontario is consumed in these four areas. Among these, the Toronto and London areas have substantial high quality aggregate resources. Both areas have enough possible resources to last for several decades, even if a significant part of these resources could not be accessed for environmental or other reasons.

Why is the Ontario government then concerned with the potential need for transporting aggregates from remote sources?

The reasons for the concern are the effects of mineral aggregate extraction and distribution on the land, on the people and on their environment.

Aggregates are extracted from land which otherwise might be used for agriculture. Some production sites have been a source of annoyance to adjacent residents. As well, trucks hauling millions of tonnes of sand, gravel or crushed stone often cause congestion, noise, dust and safety hazards. This has given rise to strong opposition by local residents to the licensing of new pits or quarries in many parts of Ontario.

Hence, very few new licences were granted in the Toronto and London areas in recent years while the consumption of aggregates continued to deplete the existing licensed sources.

If no new licences were granted in the future, the existing licensed resources would be depleted by the early 1990's in the London area and around the year 2000 in the Toronto area.

A solution must be found therefore to secure the supply of mineral aggregates to the urban areas. Aggregates are vital to construction and it is estimated that in Ontario, one job in ten depends directly or indirectly on their availability.

Transportation of aggregates from remote sources is one of the often proposed solutions to the problem. It is reasoned that the effects of aggregate production and distribution on people and on the environment are less in certain geographic areas than in others. If that was found to be true, mineral aggregates should be produced in such areas and transported to the markets by the most effective means, provided that costs are acceptable.

Two areas were selected as representative of potential future sources of supply:

- The Saugeen area, which includes parts of Grey, Huron and Bruce Counties. The area has a large supply of sand and gravel.
- Manitoulin Island. The island has ample supplies of limestone.

The purpose of this study was to find the most effective means of transportation from the selected source areas to the selected markets, and to determine their costs and impacts. The long distance transportation option was then compared with other possible solutions to the conflict between the need for aggregates and the protection of the natural and social environment.

These are the major conclusions of the study:

- Long distance transportation of mineral aggregates would increase the price of the delivered products substantially. For example, the average price of delivered aggregates in the Toronto area was $4.55 per metric tonne in 1979. This price would increase by more than 50 percent to at least $7.00 if the material was brought to Toronto by rail from the Saugeen area. The price increase would be even higher if the aggregates were transported from a greater distance, such as Manitoulin Island, or by other methods of transportation, such as trucks or ships.
- Even the minimum price increase would cost the Toronto area consumers approximately $100 million annually. The rail transportation system would require additional capital investments in excess of $400 million over the investments required for a system of continuing local supply and would consume almost twice as much fuel as the local supply system.
- For the London area, long distance rail haul would almost double the price of aggregates, increasing it from an average of $3.90 to $7.60 per tonne. This would cost London consumers an additional $20 million annually and require an initial investment of $90 million.
- Windsor and Sarnia already rely on long distance transportation for the supply of crushed stone. The delivered price of crushed stone in these areas is presently in the broad range of $7.00 to $8.00.
- The impacts of aggregate production sites on agricultural land and on the natural environment would not be reduced significantly by moving production further away from the population centres. Provincial policies related to the rehabilitation of aggregate production sites and local licensing procedures already prevent most of the harmful effects of aggregate extraction that have occurred at some locations in the past. As long as similar principles of protection are ap-

plied throughout Ontario the impacts of aggregate production would not be much more severe in one area than in another.

- The numbers of local residents affected by the extraction and associated transportation of aggregates near the production sites would be smaller in a remote source area. However, the impacts on the communities may not be less because of the concentrated nature of the operations. In addition, many people would be affected by rail line relocation and by the heavy traffic on the rail lines. For example, between Saugeen and Toronto rail traffic would increase from a few short trains per week to 48 long trains per day.
- The only significant reduction of impacts that could be achieved through the long distance transportation of mineral aggregates would be a reduction in the harmful effects of trucking in the Toronto area. The rail receiving terminals could be located adjacent to Toronto's freeway network to make it possible for distribution trucks to move directly onto the highways without disturbing people along local roads. This is the major advantage that would have to be weighed against the costs of a long distance transportation system.
- The question must be asked whether the harmful effects of the trucking of aggregates on local residents could not be reduced by other means? Could the same results be achieved at substantially lower costs?
- The following measures could significantly reduce the impacts of trucking:
  - Construction of new access roads between aggregate extraction sites and major roads.
  - Giving greater recognition in the Ministry of Transportation and Communications' municipal roads subsidy program for improving municipal roads used for aggregate haulage.
  - Designating certain routes for aggregate hauling.
  - Enlarging the road surfacing program so that all roads used for significant aggregate haulage would be hard surfaced.
  - Recognizing the special requirements for aggregate traffic in road improvement programs to minimize interference with other traffic; examples are truck climbing lanes and improvements at intersections.
  - Maintaining and enforcing regulations related to the sizes, weights and speed of aggregate trucks.
  - Considering new legislation to provide for additional control over the movement of aggregate vehicles to minimize the aggravation to adjacent residents and other motorists.
- These measures could improve conditions in all supply areas, including those selected for this study. In contrast, long distance transportation may not always achieve equal results since a freeway network similar to that of the Toronto area is required to reduce the disturbance caused by aggregate trucks. For example, if rail distribution terminals were located in the London area, the harmful effects of aggregate trucking near those terminals would be greater than the effects of trucking near existing aggregate production sites, since the latter are generally dispersed throughout the area.
- Significant volumes of mineral aggregates are presently supplied to Windsor and Sarnia from sources in the United States. Most of these aggregates consist of crushed stone shipped from Michigan by water. The study showed that the stone could be supplied to Windsor and Sarnia from Manitoulin Island instead of the United States at approximately the same prices. However, only a large production and shipping facility would be economically viable.

CHAPTER 1
Introduction

Mineral aggregates are materials essential for most types of construction.

Those types of construction that depend on mineral aggregates account for approximately 10% of Ontario's Gross Provincial Product. Thus, approximately ten percent of the jobs in Ontario are directly or indirectly affected by the supply of mineral aggregates.

The proposed Ontario Aggregates Act defines mineral aggregates as "gravel, sand, clay, shale, stone and earth". In this study the term "mineral aggregate" was restricted to gravel, sand, and crushed stone, used for construction or industrial processes.

The annual production of these aggregates in Ontario currently averages approximately 125 million metric tonnes. This volume is greater than the combined volume of all minerals produced in Canada with the exclusion of aggregates. Thus, Ontario alone produces more mineral aggregates than the combined amounts of iron ore and all other ores, coal, potash, gypsum and salt mined in the entire country. These amounts must be transported from their sources of production to their points of use.

Fortunately, large deposits of mineral aggregates have existed at many locations throughout Ontario, including aggregates of good quality in the central region and in some parts of the southwestern regions of the Province. Consequently, there has been relatively little need for long distance transportation and this resulted in generally low prices for delivered aggregates.

The mere existence of a mineral deposit is, however, not sufficient to represent a source of supply in practical terms. The material must also be economically accessible.

In many instances, the extraction of aggregates from existing technically suitable deposits may not be feasible for several reasons:

- the land over, or in the vicinity of the deposit has been built on
- the area is used or reserved for recreational purposes
- environmental reasons prevent extraction in the area
- other land uses, such as agricultural or industrial, compete for the area
- access is difficult because of the terrain or a lack of suitable roads
- ownership of the land does not permit extraction

As cities have grown in size, population densities increased near existing gravel pits or stone quarries. This growth has created several concerns.

1.1 CONCERNS

There appears to be a general consensus in Ontario that mineral aggregates are vital to the economy and that their production should therefore not be curtailed within the Province. It is also clear that recycling and substituting other materials can only be considered a partial solution. However, despite the generally recognized need for the extraction of mineral aggregates, there are conflicting views regarding the specific locations at which their extraction should be allowed.

The largest volumes of aggregates are consumed in the densely populated areas of Ontario where construction activity is the highest. To minimize construction costs, the construction industry favours sources of aggregate supply that are as close to the points of use as possible. Short transportation distances result in lower prices and more flexible service than supply from long distances.

However, these objectives are in conflict with certain social and environmental concerns that would suggest the extraction of mineral aggregates at considerable distances from the densely populated regions.

These concerns stem partly from the environmental impact of gravel pits, stone quarries, and related truck movements and partly from land uses that may be preferred over the extraction of aggregates where land suitable for other activities is scarce.

Distant extraction areas usually offer the following advantages:

- relatively low densities of population, so that the extent of disturbance to the local population is minimized
- land that is suitable for aggregate extraction but not for other activities (i.e., it is not prime agricultural land or land with high quality recreational potential)
- needs for more diversified employment opportunities.

These advantages must be weighed against certain potential disadvantages, including:

- high transportation costs
- less flexible or reliable service due to increased transportation lead times for placing or changing purchase orders and less choice of alternate supply sources
- higher consumption of transportation fuel, contrary to the national objective of energy conservation.

The relative advantages and disadvantages of mineral aggregate production in remote areas are examined in

detail in this study, and compared with the production of aggregate in areas close to population centres.

1.2 PREVIOUS STUDIES CARRIED OUT BY THE MINISTRY OF NATURAL RESOURCES

The Ontario Ministry of Natural Resources has carried out a series of studies in recent years to examine the availability of mineral aggregates in various regions of the Province, to forecast future needs, to identify alternatives for supply, and to develop policies for resource management.

The following studies have been completed and published:

"Mineral Aggregate Study, Central Ontario Planning Region", Proctor and Redfern Ltd., 1974.

"Mineral Aggregate Study & Geological Inventory, Eastern Ontario Region", Proctor and Redfern Ltd., and Gartner Lee Associates, 1975.

"Mineral Aggregate Study and Geological Survey, Southwestern Region of Ontario", Proctor and Redfern Ltd., and Gartner Lee Associates, 1976.

"Sudbury Area, Mineral Aggregate Study", Proctor & Redfern Ltd., 1978.

"Mineral Aggregate Study for the Thunder Bay Area", James F. MacLaren Ltd., 1978.

"A Policy for Mineral Aggregate Resource Management in Ontario", Report of the Ontario Mineral Aggregate Working Party, 1976.

1.3 THE ONTARIO MINERAL AGGREGATE WORKING PARTY

The Ontario Mineral Aggregate Working Party was established in December 1975 to provide advice and assistance to the Ontario government on mineral aggregate policies. Members of the Working Party included representatives of the Provincial and local governments, the aggregate industry, and the public.

The Terms of Reference of the Working Party included the following tasks:

- to recommend an effective and broadly acceptable mineral aggregate resource management policy for Ontario
- to consider and recommend ways and means of implementing that policy, including new legislative requirements
- to solicit public viewpoints relating to the above matters by accepting briefs and holding public discussions with interested persons.

The Working Party identified the following priorities:

- Maximum utilization of available resources.
- Provincial control over the establishment, operation, development, and rehabilitation of sand and gravel pits, stone quarries, shale and clay workings, to be applied uniformly and to ensure that all such operations conformed to certain basic regulations designed to:
  - minimize unsightly appearance and aggravating conditions associated with these operations
  - encourage progressive rehabilitation and enforce ultimate rehabilitation
  - guarantee that adequate funds are available to implement the rehabilitation requirements.
- Initiation at the municipal level of the formulation of basic policies as to where pits and quarries are to be located; development of these policies to be part of a total municipal planning program which should be expressed in an official plan.

The Working Party concluded that any legislation to control the extraction of mineral aggregates in Ontario must ensure:

> "a commitment on the part of the municipalities, the aggregate industry, the Provincial government and all segments of the community at large to ensure that the transgressions and unreasonable trespassing against our environment and our quality of life by the extraction industry in the past will cease, and that these operations will in the future be conducted under legislation that is broadly acceptable and enforced under regulations that are enforceable."

The Working Party also concluded that:

- within the guidelines of the above commitment, the Provincial policy should be structured to ensure that adequate supplies of aggregate resources are made available in a competitive situation in the appropriate locations
- resource extraction in a designated area will only be acceptable if local interests are considered first.

In total, 64 recommendations were made by the Working Party. Several of these recommendations concerned the need for further research, including research in the following areas:

- studies of available resources and reserves
- studies of alternative sources of supply, including opportunities for underground mining
- development of more accurate techniques for forecasting the demand for mineral aggregates
- studies of various methods of transportation, including transportation by rail, water, and truck over relatively long distances
- studies of rehabilitiation methods
- studies related to substitute materials and conservation of aggregates.

A series of studies related to possible resources have already been carried out by the Ministry of Natural Re-

sources and were listed earlier in this chapter. Several studies related to rehabilitation have also been published.

To comply with the remaining recommendations of the Working Party, additional study was needed for:

- the development of more precise forecasts of the demand for mineral aggregates
- detailed examination of the most effective methods of transportation over a wide range of distances by all feasible transportation modes.

1.4 OBJECTIVES OF THIS STUDY

Acting on the recommendations of the Ontario Mineral Aggregate Working Party, the Ontario Ministry of Natural Resources commissioned the present study to meet the following objectives:

- to forecast the future demand for mineral aggregates for four typical market areas of Ontario: Toronto, London, Windsor, and Sarnia
- to reconcile these demands with projected supplies in the areas under study
- to estimate the additional materials that will have to be supplied by long distance transportation or by other means
- to evaluate various options for the transportation of mineral aggregates to the selected market areas
- to indicate the most effective alternatives, considering costs and environmental factors
- to determine the transportation and handling costs that would have to be added to the price of aggregates if production close to markets became infeasible.

Several other areas of research, not originally specified in the study's Terms of Reference, were also addressed in broad terms:

- the feasibility of the underground mining of stone
- the potential for substitute materials
- the continued utilization of local supplies, as compared with the option of long distance transportation
- the reduction of demand resulting from higher aggregate prices.

1.5 SCOPE OF THE STUDY

The Ontario Ministry of Natural Resources specified that the present study was to:

- provide a clear and detailed description and evaluation of the various transportation options for mineral aggregates
- ensure a thorough understanding of a system in which sand, gravel, and stone would be transported over long distances instead of the short hauls presently encountered at most locations in Ontario.

  The findings of the study were to be provided in a manner that could be followed easily by readers who were not necessarily familiar with complex transportation or mineral processing technologies or involved analytical techniques.

Two different approaches to the study were possible:

- Develop a transportation model for the entire Province of Ontario, including a large number of transportation links. Because of that large number, each link would have had to be treated in a superficial way and evaluated in broad terms.
- Select a relatively small number of transportation links and study them in detail.

The Ministry of Natural Resources chose the latter approach. Four demand areas and two supply areas were selected for the Study.

The four demand areas selected in southern Ontario were Toronto, London, Windsor, and Sarnia. These are shown in Exhibit 1-1 and consist of the following municipalities:

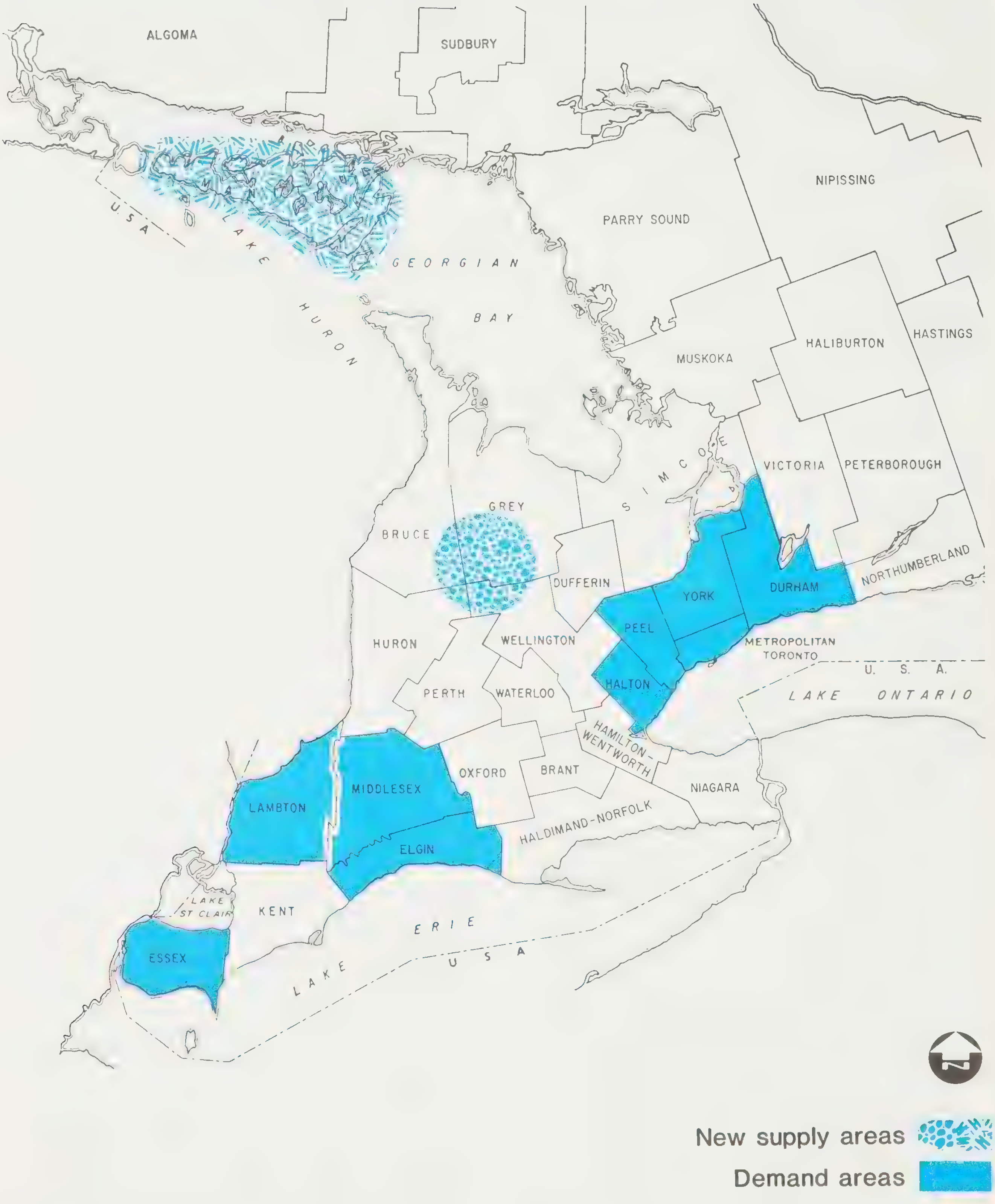
- *Toronto Demand Area*: Metropolitan Toronto and the Regions of Halton, Peel, York, and Durham
- *London Demand Area*: Middlesex and Elgin Counties
- *Windsor Demand Area*: Essex County
- *Sarnia Demand Area*: Lambton County

These are typical, high density, urban agglomerations, where the environmental and land use problems associated with local aggregate extraction are the most severe. They contain approximately 45% of Ontario's population and consume approximately 37% of all mineral aggregates used in Ontario.

The two supply areas selected were the "Saugeen" area (comprising parts of Grey, Bruce, and Huron Counties) and Manitoulin Island. The former area contains a large supply of sand and gravel, the latter of stone. The supply areas are shown in Exhibit 1-1.

The Terms of Reference for the study specified that all feasible methods of transportation should be evaluated from the two source areas to the four demand areas. These methods were to include transportation by truck, rail and, where applicable, by water and pipeline. Combinations of these modes of transport were also to be considered.

Each transportation option from each source area to each demand area was described in detail and evaluated in the study. The feasible options were then identified and their implications compared with those of continuing with the present system of aggregate supply.



STUDY AREAS 1-1

1.6 APPLICABILITY OF FINDINGS

The results of the study can be used directly for the selected demand and supply areas. However, the conclusions can also be applied in a more general way to routes and areas elsewhere. Although conditions may differ in detail, many of the conclusions relating to the feasibility and relative merits of the various transportation methods are equally valid for other geographic regions with characteristics similar to those of Toronto, London, Windsor, or Sarnia and for supply areas at distances comparable to those examined.

In an even broader sense, the approach used in the study can be viewed as a general method of analysis and evaluation that can be applied to other transportation studies related to practically any bulk material that has to be transported over long distances, either because of its unavailability in the vicinity of its markets or because its production has become prohibited for environmental or other reasons.

CHAPTER 2
Summary and Conclusions

2.1 FUTURE DEMAND FOR AGGREGATES

During the past 20 years the consumption of mineral aggregates increased by an average annual rate of 1.6% in Ontario. As shown in Chapter 3, the growth has been uneven. After a fast growth until 1965, consumption has levelled off in a range of 115 to 135 million metric tonnes per year.

In order to predict future demand for aggregates, historical data were examined in detail and separate forecasts of consumption were prepared, using different methods for four end uses:

- *Road Construction.* Some 40% of all aggregates are used for this purpose in Ontario. Modified designs and significant efforts at recycling indicate a reduction in the use of aggregate for road construction in the future.
- *Residential Building Construction.* The housing industry will decline over the next two decades due to declining birth rates; its share of aggregate consumption, though not large, will decline as well.
- *Concrete Production.* This significant user of aggregates is very closely related to economic activity and hence, the Gross Provincial Product. Projections for the future indicate resumption of growth and an increase in concrete production.
- *Non-Residential Building and Non-Road Engineering Construction.* This category was defined to include all other uses of mineral aggregate. The activity in these areas, and hence aggregate consumption, is also related to the Gross Provincial Product and is predicted to resume growth.

Predictions of continued economic growth indicate that annual consumption may be 40% higher in the year 2000 than today. This estimate was based on economic growth forecasts made by the Economic Council of Canada, projected into the longer term.

Under more pessimistic projections of economic growth, annual consumption of mineral aggregates was forecast to remain approximately at present levels.

Past history shows that even in times of no economic growth there is significant construction activity and a significant demand for aggregates. They are used for replacement, renewal and rebuilding of existing plant.

Potential substitute materials were reviewed in detail. Because of the current low price of aggregates (less than ½ cent per kilogram in most regions) it is very doubtful whether any other product could be used which would have a significant impact on the market.

Recycling of aggregate will become more prevalent in the future but almost completely in road construction. It is a major activity being pursued by the Ministry of Transportation and Communications and will become more popular with other road authorities. However, the major impact will be in resurfacing. Consumption for that use will likely drop by more than half but resurfacing is usually less than 10% of a road program and, therefore, the reduction in aggregate demand resulting from recycling is not expected to be very significant.

Where aggregates are currently plentiful, the change of the road surface reflects this. If aggregate prices were to increase as a result of long distance transportation, new road designs would be adopted that use less aggregate. Such designs are already being used in the Windsor and Sarnia areas where aggregate prices are high. In the Toronto and London areas increases in aggregate prices ranging from 50 to 100 percent would cause a 5 to 10 percent reduction in the overall amount of aggregates consumed in the areas.

It can be expected, therefore, that a substantial increase in aggregate prices caused by long distance transportation to the Toronto and London areas would cause a total reduction of less than 15 percent in the forecast total mineral aggregate demand.

The study has, therefore, determined the continuing need for supplying large volumes of mineral aggregates regardless of the rate of future economic growth.

The various ways in which these volumes of aggregates can be supplied to the Toronto, London, Windsor and Sarnia areas and the impact of the various supply methods are summarized separately for each area below.

2.2 SUPPLY OF THE TORONTO AREA

This area consumed 33 million metric tonnes of mineral aggregates in 1977. These were supplied from numerous producers located in the general proximity of the markets. Production of over one half of the total is in three general areas:

- Halton Hills, west of Metropolitan Toronto
- Caledon, northwest of Metropolitan Toronto
- Uxbridge, northeast of Metropolitan Toronto

Reserves are extracted, processed and hauled to the consumer almost completely by truck. Rail haul services a declining proportion of the market: currently 7%.

Currently licensed reserves in the Toronto area and at locations presently supplying the area are estimated at 1.1 billion tonnes. If no new aggregate pro-

duction sites were licensed in the Toronto area and the consumption of aggregates followed the higher forecasts, these licensed reserves would be depleted around the year 2000.

At current rates of comsumption, licensed reserves would last until 2010.

In order to ensure the continuing availability of mineral aggregates required by Ontario's industries, licensing of new sources of aggregate or the provision of alternate sources of supply must be considered in the near future. This study examined three basic choices for supplying the necessary amounts of aggregates to the Toronto area:

- Transport aggregates over considerable distances from source areas where suitable aggregates are available in large quantities and where some of the environmental impacts are smaller than in the Toronto area.
- Extract stone from underground mines developed within the Toronto area for blending with aggregates extracted from surface sources.
- License new production sites in existing production areas.

The following is a summary of the conclusions derived from the study regarding each of the three basic options.

2.2.1 Long Distance Transportation

One option for the future supply is to transport aggregates from remote source areas where aggregate extraction and transportation can be designed so that they are less disruptive than extraction and transportation in the Toronto area.

This study considered as examples of remote sources:

- the Saugeen area, comprising part of Grey, Huron and Bruce Counties, for sand and gravel
- Manitoulin Island for stone.

With proper planning it would be possible to extract mineral aggregates in these areas with less environmental disruption than in the Toronto area. The densities of population are relatively low and the areas are not built up to the same extent as the Toronto area. It is therefore easier to design and implement a less disruptive production and transportation system there then in densely populated and built-up areas.

This is not to suggest that there would be no impact on the Saugeen and Manitoulin area residents. It would still be necessary to dislocate some people and compensate others, likely expropriate substantial areas of land, so that an environmentally acceptable system can be developed. Whereas the number of people affected in the Saugeen area would be lower than in the Toronto area, the intensity of disruption could be greater because of the concentration of extraction.

There would be other costs associated with the system:

- *The cost of long distance transportation.* The present average distribution distance of 35 kilometres in the Toronto area would be replaced by distances ranging from 160 to 195 kilometres from the Saugeen area and a minimum of 380 kilometres from Manitoulin Island.
- *The increase in transportation fuel consumption* resulting from these distances.
- *The environmental effects of long distance aggregate transportation.* Although these effects could be reduced in the production areas, it is not possible to design a long distance transportation system that would not have an effect on the population and on the environment between the producing and consuming areas.

(i) Rail Transportation—Saugeen to Toronto Area

Several transportation methods were compared for an annual volume of 40 million metric tonnes of sand and gravel. This corresponds to the "continued growth" forecast of the Toronto area aggregate consumption in 1990 when approximately one half of the presently licensed reserves would be depleted. At that time alternate sources of supply would have to be considered to prevent a complete depletion of supplies around 2000 and the shortages that would develop in the meantime.

It was found that unit trains dedicated to aggregate traffic would be the most economical means of transportation. The trains would consist of four diesel locomotives and 80 cars, and each train would carry 7230 tonnes of aggregate. In each direction 24 trains would be required. They may be split between two rail lines: C.P. and C.N.

However, the effects of 12 unit trains per day in each direction, on each of the two lines passing through communities presently not disturbed by more than a few trains per week, is serious. This situation would be aggravated by the need for many grade separations. To alleviate this problem, it appears financially sensible and more effective to relocate certain parts of one rail line to avoid all built-up locations and assign the entire aggregate traffic to it. This line would logically be the CP line from Durham to Brampton. The line would have to be double-tracked for its entire length from the Saugeen area to Toronto to carry the entire traffic.

The environmental effects of rail traffic along this partially relocated rail line would be substantially less than along the original lines. However, associated effects would then be experienced by residents previously not disturbed by rail movements. Although the number of affected people would be much smaller than the number along the original line, the significance of the change could delay or block the approval of new rail alignments or require substantial compensation.

If the most efficient rail transportation system were implemented, the average delivered price of sand and gravel in the Toronto area would be at least

$7.00 per tonne at 1979 price levels, compared with the present average price of $4.55: an increase of $2.45 or 53% over 1979's price. This is, however, only the lower limit of the potential price increase since it implies:

- that the railways will not charge more than the rates that would provide them with a contribution to fixed costs that is equal to the *average* contribution that they obtain from their profitable traffic
- that government will rebuild the rail line that would carry the aggregate traffic, resulting in lower costs due to lower rates of return on investment required by government as compared with the railways.

This method of long distance transportation would thus cost the consumer at least $100 million every year over and above the cost of aggregate produced by present methods locally.

(ii) Other Transportation Systems—Saugeen to Toronto Area

Transportation of aggregates by truck and by slurry pipeline from the Saugeen to the Toronto area was also examined. These transportation systems were rejected for the following reasons:

- Transportation by truck was found to be much more costly than transportation by rail. The average delivered price of aggregates transported by truck was found to be $9.95 per tonne at 1979 price levels, well over twice the present average price.

  The cost of truck transportation would include expenditures on a dedicated freeway built exclusively for aggregate traffic between the Saugeen area and Toronto. Such a route would be necessary since the traffic density during peak hours would be 1,440 trucks in both directions combined, or one truck every two and a half seconds. However, the provincial fuel tax and truck licence fees would provide additional revenues to the Province that would surpass the costs of the freeway; as a result there would be no need for the Province to charge special royalties to aggregates as compensation for the freeway costs.
- The additional fuel consumption for transporting aggregates by truck over an average distance of 160 kilometres instead of 35 kilometres was estimated to be 180 million litres per year. This amount would be sufficient to provide all the direct and indirect petroleum fuel requirements of a city of 40,000 people. The equivalent figure for the rail alternative would be 50 million litres.
- From an environmental point of view there is relatively little difference in effects using a new throughway dedicated to aggregate traffic and new rail line dedicated to the same purpose.

Both would cause dislocation of some people and increase disturbance to others who were previously not exposed to the vicinity of either heavy rail or heavy truck traffic.

- Long distance transportation of mineral aggregates by slurry pipeline, although comparable in costs with long distance trucking was found to be infeasible at the present state of technology. The pipeline would have to carry particle sizes up to 50 mm in diameter which is several hundred times larger than the particle sizes of coal or iron ore transported by such pipelines today and 40 times larger than sand presently carried by a tar sand tailing pipeline in Alberta. Much more research and development would be required before a slurry pipeline could be built for the transportation of sand and gravel over long distances.

  The water and energy requirements of pipeline transportation were also found to be excessive: an aggregate pipeline would require 13 times as much energy as equivalent rail transportation.

(iii) Water and Rail Transportation—Manitoulin Island to Toronto Area

- The most economical method of transportation for stone quarried on Manitoulin Island to the Toronto area was found to be a combination of ship and rail haul. The stone would be produced in the vicinity of a dock, transported by ship to a transfer port in the Midland area and from there by rail to Toronto.
- In the normal process, without incurring major extra expenses, approximately 25 percent of quarried stone is fine aggregate. Crushed stone can therefore not provide the required 45/55% mix of coarse and fine aggregates and can only be used together with aggregates from other sources. Within a supply of 40 million tonnes of aggregates for the Toronto area, the amount of Manitoulin stone could not be greater than 9 million tonnes.
- The cost of transporting 9 million tonnes of stone annually was found to result in a delivered price of $8.95 per tonne at 1979 price levels. This compares with $7.00 for the equivalent amount of aggregate produced in the Saugeen area and transported by rail.
- Stone transported from Manitoulin Island would obviously be at an economic disadvantage vis-a-vis Saugeen aggregate. Furthermore, transportation from Manitoulin does not appear to have any environmental advantage either.
- For these reasons, long distance transportation of stone from Manitoulin Island to the Toronto area was rejected as a feasible alternative.

- Transportation of stone by rail from Manitoulin Island (Little Current) to Toronto was also rejected because its costs exceeded the ship/rail transportation costs by an additional $1.45 per tonne.
- Transportation of stone by ship all the way from Manitoulin Island to Toronto via the Welland Canal was also rejected because the cost was even higher than the all-rail transportation cost and because aggregate truck traffic through Toronto's congested waterfront area was considered highly disruptive.

2.2.2 Local Underground Mining

Underground mining of mineral aggregates within the Toronto area was found to be feasible for supplying some of the area requirements. Rock would be mined underground and crushed at the surface. Since only about 25 percent of the crushed material would be fine aggregate, mined rock could not supply the entire mineral aggregate requirement of the area.

Underground mines would be excellent candidates, however, for producing aggregates in combination with open pit extraction.

Underground mines have a much smaller surface land requirement than open pits and can, therefore, be developed closer to the points of consumption. Furthermore, they could possibly be developed adjacent to the Toronto area freeway network, significantly reducing the effects of aggregate truck operations on area residents.

Underground mines would make use of limestone that lies approximately 400 metres below the Toronto area, offering flexibility in siting surface facilities at environmentally suitable locations. However, mineral rights would have to be obtained for areas as large as 1,000 acres: a very difficult task in the densely populated Toronto area. Because of this problem, the choice of sites may be limited to larger blocks of land such as airports or other government owned properties.

The costs of underground mining would be higher than those of open-pit mining. The average delivered price of stone purchased from an underground mine would be $5.95 per metric tonne at 1979 price levels instead of an average price of $4.65 for stone produced by conventional means. However, when compared with a price in excess of $7.00 for aggregates supplied from the Saugeen area, underground mining appears to be an attractive alternative.

2.2.3 Continued Licensing of Local Open Pit Extraction

The additional possible aggregate resources in the Toronto area that could be accessed under a range of environmental policies were estimated to be up to ten times greater than the reserves available at presently licensed production sites. If, for example, only one third of these resources were actually licensed, local supplies could be sufficient to the middle of the next century. Before making major investments in new long distance transportation facilities, it would therefore seem necessary to examine the implications of licensing more new local sites or, at least, protect them for future extraction.

These new production sites would be dispersed throughout the Toronto area. Aggregate trucks would continue to share the roads with other traffic and significantly affect it in the vicinity of high concentrations of production. Communities adjacent to the roads would also be adversely affected through noise, dust, road congestion and perceived safety hazards.

However, such disturbances could be significantly reduced through road improvements such as by-passes for accommodating heavy aggregate traffic at the most seriously affected locations. Such improvements could be much more cost-effective than long distance transportation and may achieve the same or nearly the same results. Considering that the least costly long distance transportation alternative would cost at least $100 million each year, the extent of local road construction and improvement that could be carried out for lesser amounts would still be very substantial.

Loss of productive farmland would result from local aggregate production, at least temporarily. This impact would be at least as significant in the Saugeen area as in the Toronto area. Although in the Saugeen area the agricultural capability of the land may be lower, its level of usage for agricultural purposes may be higher than in the Toronto area due to the smaller range of alternate industrial opportunities. Thus, impacts resulting from the loss of agricultural land in the Saugeen area may not be smaller than in the Toronto area.

The total acreage under aggregate production in the Toronto area would be slightly greater in the future than today, considering the relatively slow growth in aggregate consumption. Disruption to residents and to the natural environment caused by excavations would be similar to that encountered now. However, the environmental impacts at production sites would be reduced by rehabilitating depleted production sites and returning them to other uses. As the result of current policies, much more rehabilitation is expected to occur in the future than in the past.

The extent to which land can be returned to agricultural or other uses depends on the level of effort that is put into rehabilitation. The problems are thus specific to each site. For example, in the Saugeen area, due to the shallow depth of top soil, rehabilitation may require more careful studies and design than elsewhere but can be accomplished with results similar to those that could be accomplished in the Toronto area.

2.2.4 Comparison of Alternatives

Transferring all local production from the Toronto area to the Saugeen area would have several impacts compared with the continuation of the present system of production in the Toronto area:

- The effect on the countryside and on the people living near the pits would be similar. Since pits would be centralized and the population smaller, fewer people would be affected in the Saugeen area. However, because of the magnitude of the operation, the impacts on the affected residents would be profound.
- The transportation rail link could be designed so as to minimize impacts on adjacent lands and residents. It would directly access the distribution terminals which would be located on industrial lands near the Toronto area freeway system and would have direct access to that system. Thus, the new system could significantly reduce the effects of the current truck traffic that carries aggregates from the pits to the freeway system. This would mean reduction of the negative impacts of aggregate traffic on the roads around Toronto.
- The distribution system from the freeway system to the customer would be the same for all options. There would still be a significant number of aggregate trucks in the urban areas.
- The new transportation system would require an investment of approximately $400 million. Including the cost of this capital, the average delivered price of aggregate would increase from $4.55 to at least $7.00: a total annual increase in costs to the consumer of nearly $100 million.

2.3 SUPPLY OF THE LONDON AREA

This area consumed 5.5 million metric tonnes of mineral aggregates in 1977. These were supplied from many producers located in the general proximity of the markets, mostly in the eastern part of Middlesex County. Practically all of the material is being distributed by truck.

Currently licensed reserves in the London area are estimated at 100 million tonnes. This is a relatively small amount in relation to current consumption and if no new sites were licensed, supplies would be depleted by the early 1990's.

The need for providing new sources of mineral aggregates is therefore more imminent in the London area than at Toronto.[1]

The basic choices for supplying the necessary amounts of aggregates to the London area are identical to those available to Toronto:

- long distance transportation
- underground mining
- licensing of new production sites in the London area.

[1] *Recent discoveries in North Dorchester Township could significantly improve the supply situation for the London area.*

A comparison of costs lead to conclusions similar to those reached for the Toronto area.

Rail transportation of aggregates from the Saugeen area was found to be the most cost-effective. Since the annual mineral aggregate demand of the London area is projected to be only in the order of 6 million tonnes in the 1990's, three or four trains per day can supply the necessary quantities. This traffic does not justify the construction of a special double track line such as proposed for the Toronto area.

In all other respects the most suitable transportation system would be similar to the system described for Toronto, albeit the rail terminals would be smaller and a single receiving terminal in the London area would be sufficient.

Since there is no freeway system comparable to that of Toronto in the London area, concentrated trucking of aggregates from a rail receiving terminal near London would create more disturbance than the present system, even if two terminals were built instead of one. Considering the additional effects of the long distance haul on people along the route from Saugeen, long distance transportation appears to result in no environmental improvement over the present system of supply.

Because of the smaller volumes the delivered price of aggregates transported by rail from the Saugeen area to London would be higher than in Toronto even though the distance from Saugeen to London is somewhat smaller. It is estimated that the average delivered price of sand and gravel from the Saugeen source would be $7.60 in London at 1979 price levels. This may be compared with the present average delivered price of $3.90. Thus, long distance transportation would almost double the price of aggregates in the London area.

The total cost to the consumer would thus be in excess of $20 million each year.

In the Saugeen area the supply to London would increase the annual production of aggregates from 40 to 46 million tonnes and the requirement for new land areas from 1000 to 1150 acres, with corresponding increases in the number of residents affected.

As in Toronto, underground mining would be an attractive alternative source of supply for London. A maximum of 2 million tonnes of stone could be mined if the material underlying the London area at a depth of approximately 100 metres was found suitable. Thus, underground mining could only be a partial solution to the supply problems of the London area, but could supplement the supplies from other sources.

Regarding the third alternative, continued local supply, the same can be said as for Toronto. Since long distance transportation would cost the consumer more than $20 million per year, this amount can be used as a benchmark against which the merits of other solutions can be judged.

As in Toronto, the improvement and construction of roads and other measures in areas of truck traffic concentration could significantly alleviate the effects of

aggregate traffic. Such measures could be far more cost-effective than long distance transportaion in achieving acceptable standards of environmental quality in the affected areas.

2.4 SUPPLY OF THE WINDSOR AND SARNIA AREAS

These areas are already deficient in mineral aggregates and import significant parts of their requirements from sources in Michigan by water and truck.

The Windsor area imports approximately 700,000 tonnes of crushed stone annually from the United States by water to supplement local supplies for a total current aggregate consumption of 3 million tonnes per year. Some sand is also trucked from Michigan to Windsor.

The situation is similar in the Sarnia area. There, approximately 1.1 million tonnes of crushed stone are imported annually from Michigan sources by water to supplement local supplies. Some sand is also trucked from Michigan to the area. The total current mineral aggregate demand of the Sarnia area is 2.1 million tonnes per year.

Mineral aggregate supplies are already insufficient in both the Windsor and the Sarnia areas.

The study concluded that the Windsor and Sarnia areas have two options:

- continue reliance on United States sources for both coarse and fine aggregates
- develop equivalent Canadian sources.

Potential Canadian sources of coarse and fine aggregates are at considerable distances from the Windsor and Sarnia areas.

The most promising alternative source for crushed stone would be Manitoulin Island. It was found that annual volumes of approximately 2 million tonnes of stone could be shipped to Windsor and 1 million tonnes to Sarnia from a quarry developed on Manitoulin Island. These shipments could replace present imports from the United States.

It was found that crushed stone from Manitoulin Island could be supplied at the same delivered price as U.S. stone. The latter is presently selling at delivered prices ranging from $7.00 to $8.00 per tonne in Windsor as well as in Sarnia.

Transportation costs of sand or sand and gravel from the Saugeen area to Windsor or Sarnia would be so excessive that the material could not possibly compete with aggregates supplied from Michigan. Thus, unless supplies from the United States are interrupted for some reason, continued importing of sand from the United States appears to be the most cost-effective solution for the supply of fine aggregates.

2.5 IMPLEMENTATION OF LONG DISTANCE TRANSPORTATION SYSTEMS

There are significant differences between the four study areas with regards to the implementation of long distance transportation systems.

The development of a source on Manitoulin Island and transportation of aggregates by water to Windsor and Sarnia could probably occur without any problem in response to market conditions. No need for government intervention is foreseen.

The situation is different for the Toronto and London areas. A significant price difference has been demonstrated between locally produced aggregates and those produced at a distance. As long as such price differences exist and local supplies of aggregates are available, supply from a remote source is not viable.

As long as low-priced material was available in the Toronto and London areas, the high-priced aggregates from more remote areas would not be saleable. Investors would therefore be reluctant to provide the large amounts of capital required for the development of production facilities in the Saugeen area and for the provision of transportation and terminal equipment.

Even when supplies from licensed local sources were to approach depletion and consequently prices were to rise, investors may be cautious, in view of the known availability of large additional local resources which can be licensed at any time if circumstances changed. Thus, the viability of production in a remote area would solely depend on policies, which are always prone to change.

The conclusion must be reached that the only practical way in which long distance transportation of mineral aggregates to the Toronto and London areas can be implemented involves significant government intervention.

Among several options, the most equitable form of government involvement appears to be the formation of a marketing board or similar organization that could buy aggregates from producers in the province at local prices and sell the aggregates to consumers at a blended market price, regardless of the origin of the material. The cost of long distance transportation would be absorbed by the marketing board and spread equitably across the market at any particular location.

The local price would not have to be the same everywhere: the price near the place of production would obviously have to be lower than further away.

A marketing board or similar organization would change the competitive nature of the aggregate business in Ontario which is not likely to benefit the consumer. Even without a monopolistic marketing organization, the large transportation terminals would necessarily reduce the customers' choice and eliminate the present competitive environment to the possible detriment of both service and price.

2.6 SUMMARY

Transferring production sites to areas remote from Toronto is not required for reasons of supply—there are adequate possible resources for many years.

The primary benefit would be reduced disruption of the local population.

Long distance transportation is being considered

by the Ontario government because of the existing difficulties in reaching general consent on the licensing of the available local resources to provide for the needs of the area. Long distance transportation has also been studied to provide a more complete understanding of all the possible alternatives for the future supply of mineral aggregates.

The Ontario government has policies, has introduced legislation and carries out planning to mitigate the local effects of aggregate extraction at the sites. However, in spite of some recently introduced measures, the external negative effects of concentrated truck traffic persist.

The long distance transportation options examined in this study would cost the consumer at least $100 million per year in the Toronto area and $20 million per year in the London area even if the least costly system could be achieved.

Whereas long distance transportation would reduce the effects of local extraction on the residents of these areas, it would affect people in the new production areas and along the the transportation routes who are presently not affected by aggregate production and traffic. Careful design of the new system can only reduce these effects but not eliminate them.

Underground mining of predominantly coarse aggregates would only be a partial solution to the problem of aggregate supply, since the required fine aggregates would still have to be supplied from other sources.

Before deciding therefore, on a long distance transportation option, alternative policies and programs designed to reduce the external impacts of aggregate traffic at far less annual cost, should be considered.

Such measures are:

- Construction of new access roads between aggregate extraction sites and major roads.
- Giving greater recognition in the Ministry of Transportation and Communications' municipal roads subsidy program for improving municipal roads for aggregate haulage.
- Designing certain routes for aggregate hauling.
- Enlarging the road surfacing program so that all roads used for significant aggregate haulage would be hard surfaced.
- Recognizing the special requirements for aggregate traffic in road improvement programs to minimize interference with other traffic; truck climbing lanes and improvements at intersections are examples of this.
- Maintaining and enforcing regulations related to the sizes, weights and speed of aggregate trucks.
- Considering new legislation to provide for additional control over the movement of aggregate vehicles to minimize the aggravation to adjacent residents and other motorists.

These improvements would cost the Ontario government money, either directly or through its subsidy program to municipalities. However, the alternative of long distance aggregate transportation would also cost the provincial Ontario government money, since the Province and the provincially subsidized municipalities are major purchasers of aggregates. It is likely that the long distance option would actually cost more.

Thus, the savings by the private sector and by the unsubsidized municipal sector resulting from the continuation of local aggregates supply under improved traffic conditions would represent a net saving for the total economy.

CHAPTER 3
The Need for Mineral Aggregates

3.1 THE CLASSIFICATION AND USE OF MINERAL AGGREGATES

3.1.1 Classification of Mineral Aggregates

There are two major categories of mineral aggregates:

- sand and gravel
- crushed stone.

Sand occurs in combination with gravel; both are excavated from open pits. They consist of a mixture of coarse and fine material. [1] The coarse material may be crushed to desired sizes.

Stone is produced in quarries where rock is blasted and crushed to required sizes. Crushed stone usually contains about 25% fine particles as a result of the crushing. Most of the stone used in Ontario is produced from limestone or dolostone.

The difference between a gravel pit and a stone quarry is the consistency of the material: in the former, the material is deposited in an "unconsolidated" form, in the latter, the material is found in a "consolidated" form.

Crushed stone is interchangeable with gravel for many applications but not all. The most important specifications are those of particle sizes and their proper proportion, though physical and chemical properties are also important.

For the purpose of this study, all demand and supply statistics and forecasts were divided into two major categories: coarse and fine aggregates. Varying proportions of these categories are specified for the materials required for various purposes.

Typically concrete and concrete products require 55% coarse and 45% fine aggregates. Road construction requires 45% coarse and 55% fine aggregates. It was found that, in total, all four study areas use approximately 45% coarse and 55% fine aggregates.

3.1.2 The Use of Mineral Aggregates

The primary use of mineral aggregates is in construction, where the principal end uses are:

- *Concrete and concrete products*. Mineral aggregates are the principal ingredients of concrete, together with cement. The main component used in the manufacture of cement is limestone, which is also a mineral aggregate. Concrete [2] is used for a wide range of construction purposes, as described below, both in the form of concrete poured on site, and in the form of prefabricated concrete products, such as blocks, bricks, tiles and pipes.
- *Road construction*. Mineral aggregates are used in their natural granular form for embankments, backfill, drainage facilities and as ingredients in asphalt [3] and concrete.
- *Engineering construction*. Aggregates are needed for a wide variety of construction applications, such as airports, marine docks, dams and parking lots. In addition to their use in the form of concrete and asphalt, they are also used in large quantities in their natural form as foundations or fill material. Aggregates are also used as backfill in the construction of services such as sewers and water mains.
- *Residential and non-residential building construction*. In addition to being used in the form of concrete and concrete products in building construction, mineral aggregates are used in the foundations of buildings and driveways, as ornamental stone and for fill.
- *Railroad ballast*.
- *Industrial applications*. Special mineral aggregates, such as limestone and dolostone are used for various industrial processes, particularly in the steel and chemical industries.

3.2 METHODS OF FORECASTING THE DEMAND FOR MINERAL AGGREGATES

The report on " A Policy for Mineral Aggregate Resource Management in Ontario", prepared by the Ontario Mineral Aggregate Working Party, identified the need for a more refined method of predicting the demand for mineral aggregates in Ontario as a whole and in its various regions.

Accordingly, after substantial experimentation, separate forecasting methods were developed for four groups of construction categories.

1. *Road Construction*. It was found that road construction and the amount of mineral aggregates consumed for that purpose are not directly related to changes in either the population or the Gross Provincial Product. Although there is a long-term relationship between these factors, the time periods over which such relationships can be detected

(1) *Aggregate is defined as coarse if it is retained in a sieve that has openings with sides of 6.35 milimetres (¼ inch). Fine aggregate is the material that passes.*
(2) *In this report, the term "concrete" refers to products containing portland cement as binder and mineral aggregates.*
(3) *In this report, the term "asphalt" refers to asphaltic concrete consisting of asphalt cement and mineral aggregates.*

are so great that they cannot be used for forecasting, even for periods in the order of 20 years.

Since it was found that changes in the activity levels of road construction do not coincide with changes in the economy, it was determined that the actual plans for Provincial and municipal road construction expenditures were a more appropriate basis for forecasting. Projections of these expenditures were available from the Ontario Ministry of Transportation and Communications for the next 10 years for Provincial highways and for the next 5 years for municipal roads. Trend projections were used to continue these forecasts into a 20-year period for each of the demand areas. Forecasts of subdivision roads were based on the forecasts of residential building construction (see below),

2. *Residential building construction.* This category of construction depends on the demand for new housing units which depends in part on changes in the age distribution of the population. Demographic forecasts, including those of age distributions, are very reliable since practically all of the people who will require new housing in the next 20 years are already alive.

   There have been substantial fluctuations in birth rates during the past decade — the post-war baby boom was followed by a more normal period of fertilitY, followed almost abruptly by rapidly declining birth rates after the mid 1960's. Immigration patterns have also changed — after an extended period of high rates of immigration to Ontario, the 1970's showed a substantial decline. The effects of these changes on the requirements for residential construction will become apparent in the latter part of the 1980's and in the 1990's when the demand for new housing units is expected to be substantially lower than in recent years.

3. *Concrete and concrete products.* It was found that the production of concrete and concrete products can be forecast with a good degree of reliability on the basis of changes in the Gross Provincial Product. A specific model was developed to forecast the demand for mineral aggregates in this category throughout the Province.

   The Provincial forecasts were then split into forecasts for the individual demand areas.

   Care was taken not to double count concrete used in road construction and in residential building construction for which separate direct forecasts were prepared as described above.

4. *Other construction.* This category includes non-residential building construction and non-road engineering construction. After experimentation, it was found that the mineral aggregate consumption of this category, excluding concrete, could be forecast by a model similar in structure to the model used for the forecast of concrete production, although somewhat different in actual form. The major variables of this model were: the Gross Provincial Product and past changes in the Gross Provincial Product. The "other construction" category excluded concrete, since separate forecasts were prepared for that category as described above.

   Because of the very nature of the various sub-categories under this heading, the best correlations could be found when the sub-categories were combined. Thus, non-residential building construction and non-road engineering construction was treated as a single category. It was also found that due to the higher production figures for mineral aggregates that resulted from adjustments by the Ministry of Natural Resources to Statistics Canada data, the "other construction" category consumed a larger proportion of the total mineral aggregate consumption of Ontario than reported in previous statistics and studies.

   The forecasts for this category were prepared for the entire Province and then broken down into individual demand areas.

The different forecasting methods developed for the four construction categories clearly indicated that a large portion of the mineral aggregate consumption does not depend on the general growth of the economy.

Road construction depends partly on Provincial and municipal budgets, partly on the development of subdivisions. The development of subdivisions and residential building construction depends on demographic changes. Thus, road construction activity may be high at times of no economic growth and, conversely, residential building activities may be low at times of strong economic growth on account of changes in the composition of the population.

Two of the forecast categories, concrete production and "other" construction, were found to depend on the general growth of the economy expressed in such terms as the Gross Provincial Product. However, even these categories are not entirely dependent on growth. It is incorrect to equate construction entirely with growth: the replacement of existing "worn out" or obsolete physical plant is an ongoing process that occurs even when the economy does not grow at all.

As proven by the results of the forecasting study (Section 3.3) a substantial demand for mineral aggregates is projected even for a very low rate of economic growth. This demand will arise in the construction sectors that are not dependent on the growth of such factors as the Gross Provincial Product.

The described forecasting methods responded to the requirement for more refined demand projections identified by the Ontario Mineral Aggregate Working Party. The forecasts incorporated the following refinements:

- A more accurate data base was established, using Ministry of Natural Resources data in conjunction with Statistics Canada data.

- New forecasting models were developed that were specifically tailored to four different demand categories; for example, the aggregate demand of road and residential building construction was forecast directly instead of relating it to general economic projections.
- The models were tested and their validity confirmed by using them to "predict" the consumption of the past 20 years.
- The amount of mineral aggregates per dollar of construction expenditure was estimated on the basis of a 20-year historical analysis.
- Forecasts of demand and supply were separated into coarse and fine classifications of aggregates.
- The sensitivity of the forecasts to economic growth was demonstrated by developing forecasts for two different economic growth projections.

3.3 FORECASTS OF MINERAL AGGREGATE DEMAND

The forecasts prepared for each of the four demand categories are described in detail in Appendix A.

Exhibits 3-1 to 3-4 show the forecasts of mineral aggregate demand in the four demand areas considered in the study. The forecasts are shown for 5-year intervals to the year 2000.

The forecasts are also shown graphically in Exhibits 3-5 to 3-8.

As described in more detail in Appendix A, for those demand categories that depend on the growth of the Gross Provincial Product, projections had to be made for that factor.

The forecasts shown in Exhibits 3-1 to 3-8 are based on the assumption of *continuing growth*. According to this assumption the Canadian Gross National Product (GNP) would continue to grow at a rate approximately equal to the average growth rate experienced in the 1974-1978 period. Accordingly, an annual real growth rate of 3.35% in the Gross National Prod-

EXHIBIT 3–1
AGGREGATE FORECASTS, TORONTO AREA, CONTINUING GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	10.3	1.6	3.0	8.7	9.1	32.7
1980	12.8	1.7	3.1	10.4	8.1	36.1
1985	12.2	1.8	3.3	12.0	8.7	38.0
1990	11.7	1.2	2.2	15.6	9.9	40.6
1995	11.3	0.6	1.1	19.6	11.4	44.0
2000	11.3	0.6	1.1	23.3	12.9	49.2

*Includes small amounts of concrete

EXHIBIT 3–2
AGGREGATE FORECASTS, LONDON AREA, CONTINUING GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	1.7	0.2	0.4	0.5	2.7	5.5
1980	2.0	0.2	0.4	0.6	2.7	5.7
1985	1.4	0.2	0.3	0.7	2.9	5.5
1990	1.4	0.1	0.2	1.0	3.3	6.0
1995	1.3	0.1	0.1	1.2	3.8	6.5
2000	1.3	0.1	0.1	1.5	4.3	7.3

*Includes small amounts of concrete

uct was assumed to continue to the year 2000. This rate, considered "most likely", corresponds to the growth projected by several sources, including projections for the 1980's contained in the Economic Council of Canada's 1979 Annual Report*.

Ontario's Gross Provincial Product (GPP) has grown at a slower pace in recent years and has been consistently lower than the growth rate of the GNP by 1.2-1.3 percentage points throughout the 1970's. It was assumed that the growth rate of Ontario's GPP would gradually come closer to that of the Gross National Product, equalling it by 1991 and thereafter.

Forecasts of mineral aggregate demand were also prepared for the Province of Ontario and are shown in Exhibits 3-9 and 3-10.

Since the forecasts of road construction and of residential building construction were prepared directly for each demand area, no Province-wide forecast was available from the results of the study. As an approximation the combined growth rates of the four study areas were used to project the Provincial demand for mineral aggregates in the road and residential building construction category.

* *Mean of three fuel-price assumptions used by the Economic Council in their forecasting.*

Exhibit 3-10 also shows the mineral aggregate consumption of the Province during the past 20 years. The graph indicates a rapid growth of consumption until approximately 1965, followed by an extended period of no growth. The overall average annual growth rate of aggregate consumption in Ontario was approximately 1.6 percent during the 20-year period.

The forecast to the year 2000, based on the "continued growth" assumption indicates an average growth rate that is approximately equal to the average growth rate experienced during the past 20 years.

3.4 SENSITIVITY TESTS

The actual demand can deviate from forecasts for two reasons:

- the general assumption underlying the forecasts does not materialize
- the forecasting method is not precise enough.

EXHIBIT 3–3
AGGREGATE FORECASTS, WINDSOR AREA, CONTINUING GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	0.7	0.2	0.3	0.4	1.4	3.0
1980	0.9	0.2	0.3	0.5	1.4	3.3
1985	0.7	0.2	0.3	0.6	1.5	3.3
1990	0.6	0.1	0.2	0.8	1.7	3.4
1995	0.6	0.1	0.1	1.0	1.9	3.7
2000	0.6	0.1	0.1	1.3	2.2	4.3

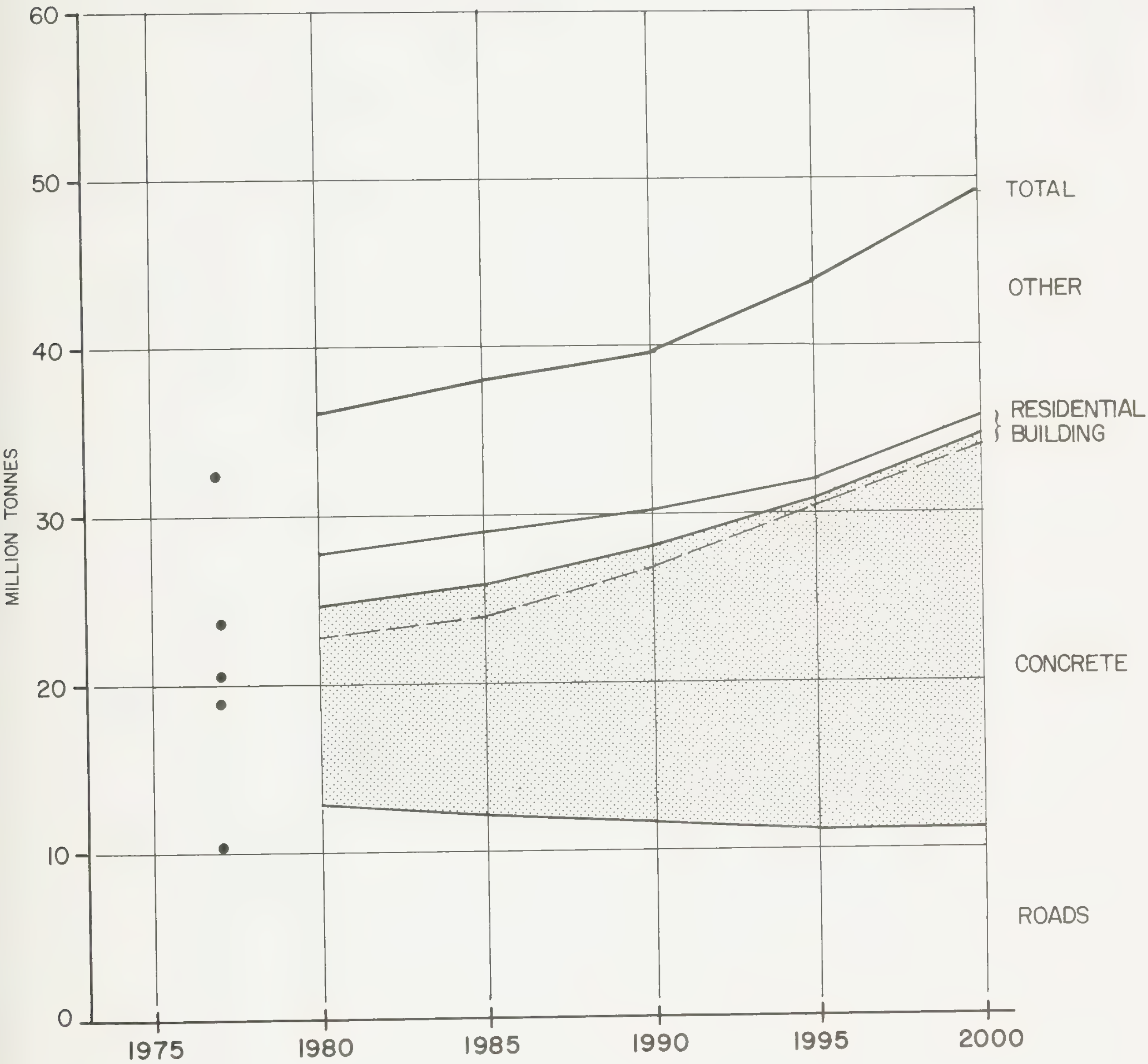
*Includes small amounts of concrete

EXHIBIT 3–4
AGGREGATE FORECASTS, SARNIA AREA, CONTINUING GROWTH

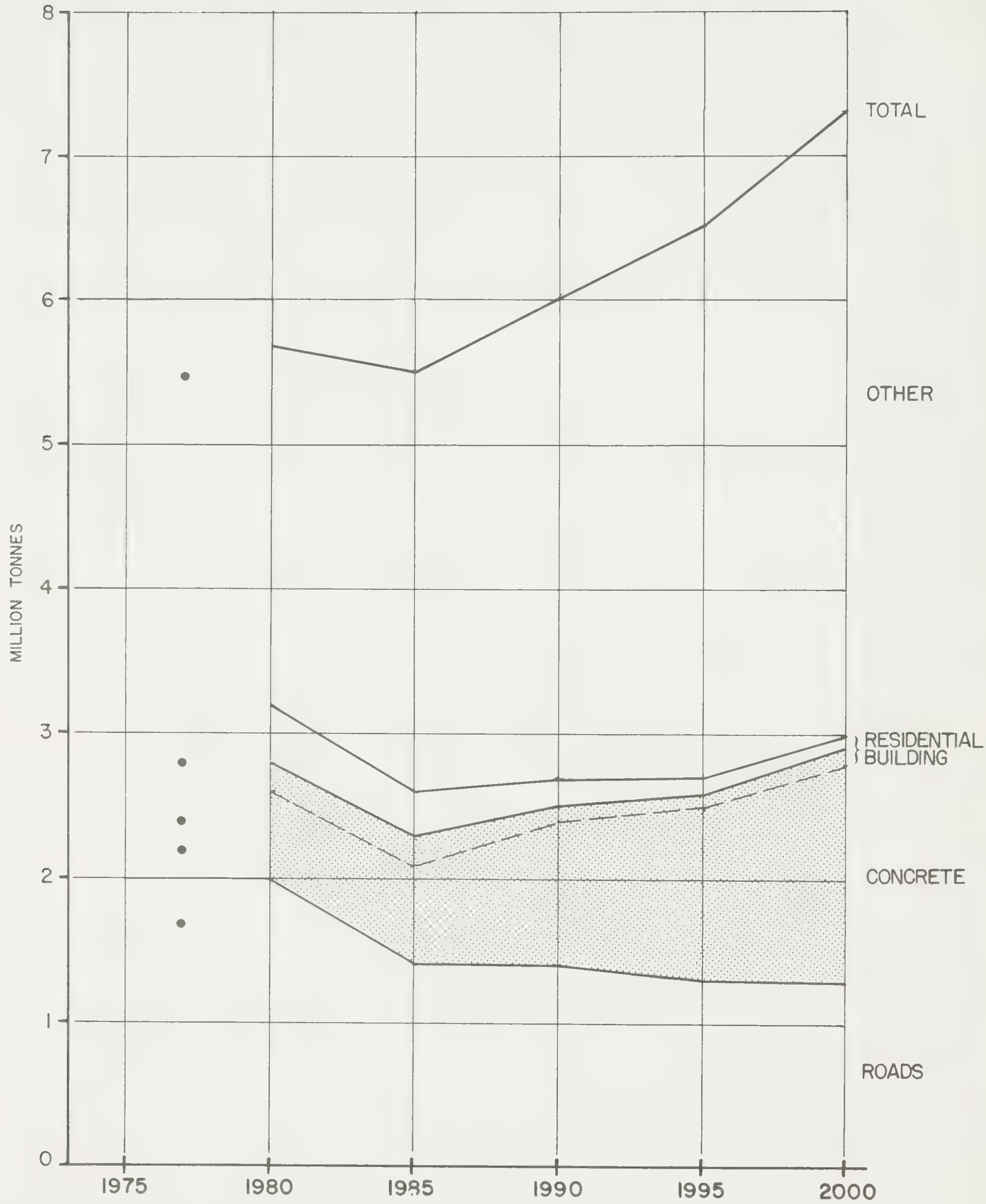
(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	0.8	0.1	0.2	0.3	0.7	2.1
1980	0.5	0.1	0.2	0.4	0.6	1.8
1985	0.5	0.1	0.2	0.4	0.7	1.9
1990	0.5	0.1	0.1	0.5	0.8	2.0
1995	0.5	0.1	0.1	0.6	0.9	2.2
2000	0.5	0.1	0.1	0.8	1.0	2.5

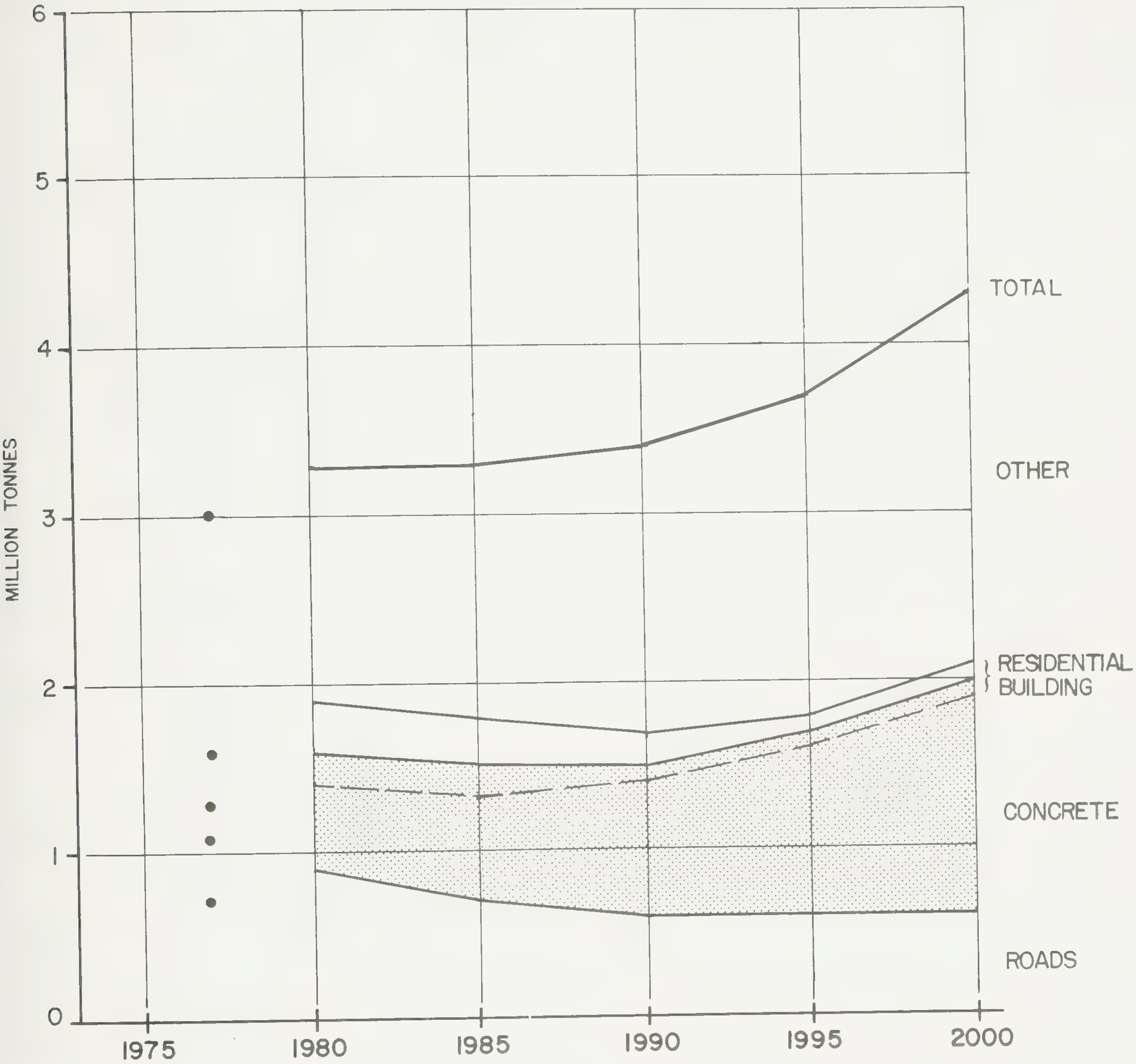
*Includes small amounts of concrete



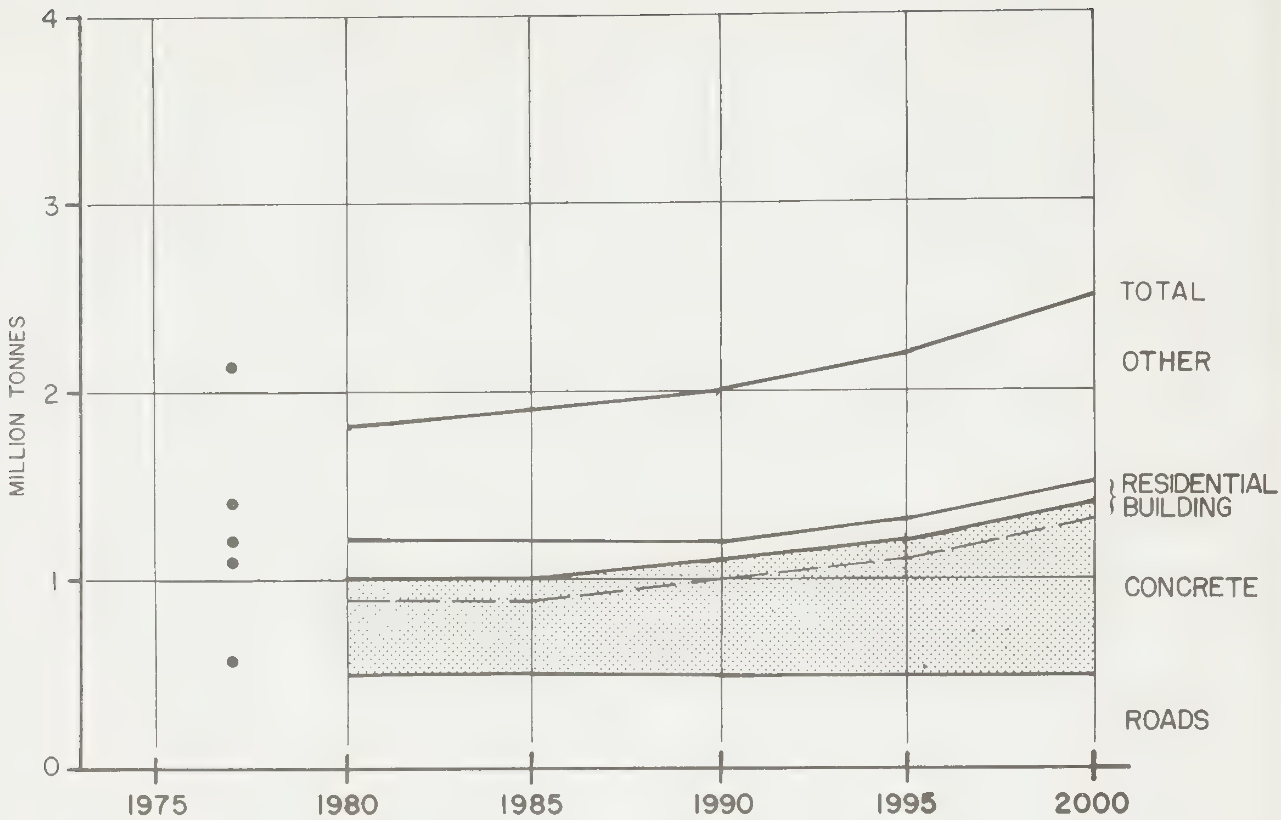
AGGREGATE FORECASTS - TORONTO AREA 3-5



AGGREGATE FORECASTS - LONDON AREA 3-6



AGGREGATE FORECASTS – WINDSOR AREA 3-7



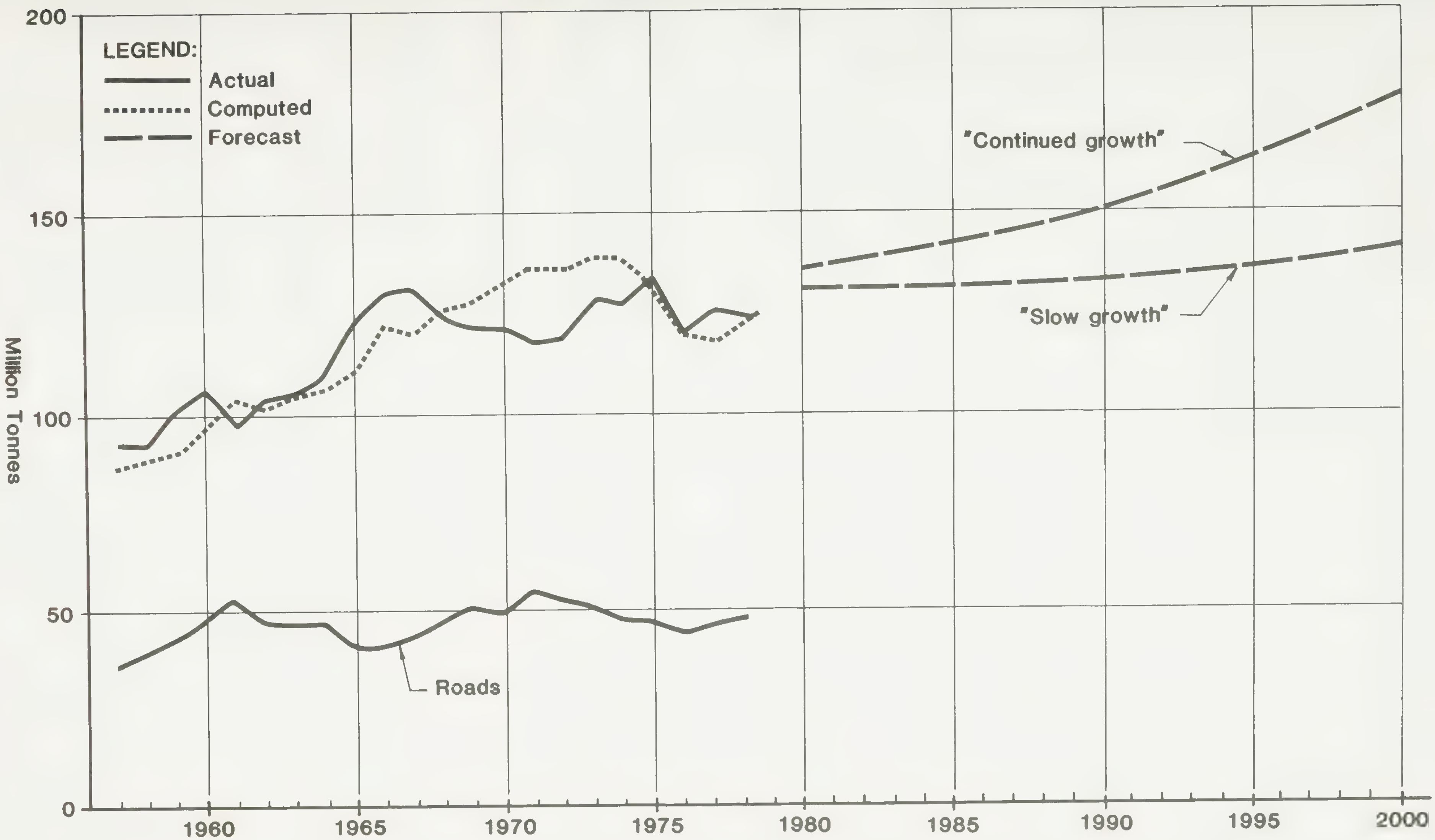
AGGREGATE FORECASTS – SARNIA AREA 3–8

EXHIBIT 3–9
AGGREGATE FORECASTS, ONTARIO, CONTINUING GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	45.8	4.1	7.8	14.3	56.6	128.6
1980	55.0	4.3	8.0	17.3	55.2	139.8
1985	50.2	4.4	8.2	20.3	59.4	142.5
1990	48.2	2.9	5.4	27.1	67.9	151.5
1995	46.5	1.5	2.8	34.7	77.9	163.4
2000	46.5	1.5	2.8	41.1	88.1	180.0

*Includes small amounts of concrete



AGGREGATE CONSUMPTION - ONTARIO 3-10

3.4.1 Slow Growth Projection

In order to test the sensitivity of the mineral aggregate forecasts to the first factor an alternative economic growth projection was made and the aggregate forecasts were repeated for that projection.

The alternative projection was based on *slow growth*, in which Ontario's Gross Provincial Product would grow at a slow rate of 1.75% per year in real terms throughout the rest of the century. This growth rate corresponds to the average real growth of Ontario's Gross Provincial Product from 1973 to 1978.

The forecasts of mineral aggregate demand for the Province of Ontario corresponding to this projection are also shown in Exhibit 3-10. The graph indicates that in spite of the slow economic growth the consumption of aggregate would remain practically at the same level for a long period of time and would rise slightly towards the end of the century.

The forecasts for the slow growth projection are shown numerically in Exhibit 3-11 for the Province. Corresponding forecasts for the four demand areas are shown in Exhibits 3-12 to 3-15.

3.4.2 Testing the Validity of the Forecasting Methods

The second reason for deviations between the actual demand and the forecasts was identified as the inability of any forecasting method to predict future events with absolute precision.

In order to indicate the margins of error that may exist between the actual demand volumes and the forecasts in the future on account of this reason, the forecasting methods were applied to *past data* and "forecasts" of mineral aggregate consumption were made. The results of these tests were then compared with the actual consumption.

Exhibit 3-10 indicates the deviations between the actual consumption of mineral aggregates in Ontario during the past 20 years and the amounts "predicted" by the forecasting method.

In most years the forecast errors were relatively small. A comparison of the curve representing the actual demand with the curve representing the "predicted" demand provides an indication of the potential forecast errors related to the imperfection of the forecasting method that may be expected in the future.

3.5 IMPACTS OF HIGHER AGGREGATE PRICES

Where aggregates are currently plentiful, the change of the road surface reflects this. If aggregate prices were to increase as a result of long distance transportation, new road designs would be adopted that use less aggregate. Such designs are already being used in the Windsor and Sarnia areas where aggregate prices are high. In the Toronto and London areas increases in aggregate prices ranging from 50 to 100 percent would cause a 5 to 10 percent reduction in the overall amount of aggregates consumed in the areas.

Recycling of aggregate will become more prevalent in the future but almost completely in road construction. It is a major activity being pursued by the Ministry of Transportation and Communications and will become more popular with other road authorities. However, the major impact will be in resurfacing. Consumption for that use will likely drop by more than half but resurfacing is usually less than 10% of a road program and, therefore, the reduction in aggregate demand resulting from recycling is not expected to be very significant.

It can be expected, therefore, that a substantial increase in aggregate prices caused by long distance transportation to the Toronto and London areas would cause a total reduction of less than 15 percent in the forecast total mineral aggregate demand.

EXHIBIT 3–11
AGGREGATE FORECASTS, ONTARIO, SLOW GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	45.8	4.1	7.8	14.3	56.6	128.6
1980	55.0	4.3	8.0	16.9	52.8	137.0
1985	50.2	4.4	8.2	17.5	54.7	135.0
1990	48.2	2.9	5.4	20.5	57.8	134.8
1995	46.5	1.5	2.8	24.5	61.1	136.4
2000	46.5	1.5	2.8	26.9	64.7	142.4

*Includes small amounts of concrete

EXHIBIT 3–12
AGGREGATE FORECASTS, TORONTO AREA, SLOW GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	10.3	1.6	3.0	8.7	9.1	32.7
1980	12.8	1.7	3.1	10.2	7.7	35.5
1985	12.2	1.8	3.3	10.4	8.0	35.7
1990	11.7	1.2	2.2	11.8	8.5	35.4
1995	11.3	0.6	1.1	14.0	9.0	36.0
2000	11.3	0.6	1.1	15.2	9.5	37.7

*Includes small amounts of concrete

EXHIBIT 3–13
AGGREGATE FORECASTS, LONDON AREA, SLOW GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	1.7	0.2	0.4	0.5	2.7	5.5
1980	2.0	0.2	0.4	0.6	2.6	5.8
1985	1.4	0.2	0.3	0.7	2.7	5.3
1990	1.4	0.1	0.2	0.8	2.8	5.3
1995	1.3	0.1	0.1	0.9	3.0	5.4
2000	1.3	0.1	0.1	1.0	3.2	5.7

*Includes small amounts of concrete

EXHIBIT 3–14
AGGREGATE FORECASTS, WINDSOR AREA, SLOW GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	0.7	0.2	0.3	0.4	1.4	3.0
1980	0.9	0.2	0.3	0.5	1.3	3.2
1985	0.7	0.2	0.3	0.5	1.4	3.1
1990	0.6	0.1	0.2	0.6	1.5	3.0
1995	0.6	0.1	0.1	0.7	1.5	3.0
2000	0.6	0.1	0.1	0.8	1.6	3.2

*Includes small amounts of concrete

EXHIBIT 3–15
AGGREGATE FORECASTS, SARNIA AREA, SLOW GROWTH

(million tonnes)

	ROADS*	RESIDENTIAL BUILDING		NON-ROAD ENGINEERING AND NON-RESIDENTIAL BUILDING		TOTAL
		Concrete	Other	Concrete	Other	
1977	0.8	0.1	0.2	0.3	0.7	2.1
1980	0.5	0.1	0.2	0.3	0.6	1.7
1985	0.5	0.1	0.2	0.4	0.6	1.8
1990	0.5	0.1	0.1	0.4	0.7	1.8
1995	0.5	0.1	0.1	0.5	0.7	1.9
2000	0.5	0.1	0.1	0.5	0.7	1.9

*Includes small amounts of concrete

CHAPTER 4

The Supply of Mineral Aggregates from Existing Source Areas

4.1 A LOOK AT THE AGGREGATE INDUSTRY

Mineral aggregates are supplied from many sources in a competitive environment.

The Aggregate Producers' Association of Ontario, which represents most of the major producers in the Province, has approximately 140 active members. About half of these supply aggregates to the four areas under study. A considerable number of pits and quarries are also operated by non-members, although their operations are generally of a smaller nature. In addition, various sources in Michigan supply the Windsor and Sarnia markets.

The industry is composed of a wide mixture of company sizes and corporate structures, from quite small family-owned operations through medium-sized private or publicly-owned companies to large producers owned or controlled by major Canadian or foreign corporations. Often these companies are also engaged in aggregate-consuming activities, such as road-building or the production of ready-mix concrete or concrete products.

Since the large number of suppliers ensures a high degree of competition, the existing selling prices are realistic. This means that whereas the industry is provided with an adequate return on its capital investment the consumers are not penalized with exorbitant prices.

4.1.1 Mix and Quality of Materials

Most operations produce several distinct products satisfying a wide range of uses. Each product has its own specifications regarding size gradations, crushed contents, particle shapes, abrasion resistance, breakdown under freezing and thawing, and chemical content. Production can be therefore highly technical, requiring sophisticated equipment and procedures as well as careful control of each stage of production. Yet these commodities are currently being supplied to customers at delivered prices usually less than one-half cent per kilogram (one-quarter cent per pound).

One of the most troublesome problems to the producer is the need to keep his inventory of products in balance as well as possible. In a sand and gravel operation, it is not possible to produce only coarse aggregates, since sand is a by-product, whether or not there is a market for it. In a crushed stone operation, the breakage of rock at each stage leading to the final desired stone size also produces finer materials, which must be handled.

If the full range of products is not promptly sold, the unwanted sizes soon build up to create a costly stockpiling problem. If they are never sold, the whole cost of the operation, increased by the cost of disposing of the unwanted material, accrues against the saleable items. Consequently, when looking at any proposed new source of aggregates, the detailed demand for the broad range of material sizes must be carefully considered in order to properly assess the probable success of the operation.

In this study, the demand in each market for coarse and for fine aggregate was determined, and then the suitability of the proposed new sources was assessed in terms of their ability to satisfy each of the requirements.

The content of sand and gravel deposits in Ontario ranges from 100% sand to approximately 70% stone and 30% sand. The suitability of the sand usually varies with the stone content — a pure sand deposit is generally too fine for making good concrete or asphalt while the very coarse sand contained in some gravel deposits is unacceptable for many purposes.

The gradation of fine aggregate in asphalt and concrete mixes is critical. Specifications permit a fair range in gradation but require a high degree of uniformity in the continuing supply. In concrete, the colour and texture of the finished product is materially affected by the nature of the aggregate, particularly of the fine aggregate. Thus, it is essential that a producer maintain tight control over his supply in order to ensure dependable quality.

The proportion of fine material produced in a crushed stone operation depends on several factors, primarily on the degree of crushing. A figure of 25% fine aggregate content in crushed stone material is used as an average in this study but this proportion can sometimes be 35% or more.

The gradation and angularity of a typical quarry fine product, while generally resembling sand in its size range and quite constant in its makeup, does not make its use in concrete or asphalt readily acceptable. Its best use is in base course materials where its nature contributes to compactability. However, problems are encountered when too much extreme fine content impedes the drainage of water from the base.

"Manufactured sand" can be produced by the cutting or grinding of stone. It is a practical method for increasing the proportion of fine aggregates within certain limits. The method is, however, highly energy-consumptive and the product, while quite satisfactory in mass concrete and in some concrete products, creates problems for many uses due to its harsh angular

shape. The most serious difficulty is caused by a significant amount of material that is reduced to unwanted extreme fine sizes, below 200 mesh. The amount of this unwanted material can exceed 20 percent of the amount of stone processed. The disposal of this material is difficult and costly, especially in the case of underground mining in an urban setting.

Accordingly, the manufacturing of fine aggregates from crushed stone sources, beyond the amounts normally derived in the routine production of coarse aggregate, has not been considered in this study.

In fine aggregates, the gradation is usually the most important quality requirement. If that is controlled, the material is usually acceptable.

In coarse aggregate, the desired size can generally be produced by the degree of crushing, but many physical and chemical specifications must also be satisfied. Various so-called deleterious materials may be present in a quarry or pit face, such as chert, shale, or siltstone, which may restrict or indeed totally prevent the use of materials from the source. Ingenious processes and equipment have been developed to "beneficiate" some of the marginal material by removing the harmful elements, and as the better deposits are depleted, these practices will become increasingly important.

Specifications that do not permit the utilization of lower quality material result in higher prices. However, the cost of aggregate is usually such a small part of the total construction cost that compromising the expected life of the finished product by using cheaper products is rarely a good practice.

4.1.2 Aggregate Plants

The demand for aggregates in Ontario is highly seasonal, since consumption in the winter months is only about 25% of that in the summer months. This, combined with the difficulties inherent in outdoor operations in the Ontario climate, causes production in most pits and quarries to be curtailed or eliminated altogether in the winter. The reduced demand in those months is satisfied by shipments from stockpiles built up in the warmer months.

It is not possible to operate a washing plant in freezing weather, so the production season is usually confined to the eight months between April and November. Although dry crushing operation can be carried on throughout the winter, the efficiency of production is affected by difficulties resulting from snowfall and extreme temperatures. Thus, the operating year for most aggregate plants is usually less than 12 months so as to avoid the worst winter conditions and to permit the overhaul of key items of plant and equipment.

There is no standard design for aggregate plants — each deposit and each range of desired products requires careful analysis and a specific design engineered for the location.

By selecting various available standard components and assembling them in combinations that provide the required crushing, sizing, cleaning, beneficiation, stockpiling, and loading, a wide variety of needs and problems can be efficiently handled. Some of the components can be purchased as portable units, thus permitting ready relocation after the depletion of a source or the satisfaction of a specific short-term need such as a highway project.

The optimum size of a plant depends on the demand for the desired quantities of product. Currently in Ontario both sand and gravel operations and crushed stone operations can be found with the annual production of most plants ranging from about 50,000 to 3 million tonnes. Due to the heavy investment required for a large fixed plant, the intended capacity should be considered in relation to the size of the deposit of raw materials available for processing. A minimum of a 20-year life would seem to be prudent for accounting purposes, since much of the investment — for footings, structures, wiring, and piping — is largely or totally unrecoverable after the deposit has been depleted. The physical life of a plant is often substantially longer than 20 years.

It is probable that a crushed stone plant and a gravel plant require approximately the same investment for the same annual capacity. Whereas the crushed stone plant requires drilling equipment, heavier excavating and hauling units, and much larger primary crushers, a gravel plant requires pumping equipment and settling ponds in connection with its washing plant and a higher hourly throughput due to its shorter operating season.

4.1.3 Prices

From questionnaires sent to producers supplying the four demand areas of the study, average selling prices were obtained for aggregates f.o.b. Plant. The following prices were reported for 1979:

- Thirteen washing plants in the sand and gravel sector, chosen from the replies as being most representative, sold nearly 10 million tonnes at an average price of $2.25 per tonne.
- Twenty-four sand and gravel pits without washing units sold over 5 million tonnes at an average price of $1.80 per tonne.
- Nine quarries sold nearly 10 million tonnes at an average price of $2.35 per tonne.

These figures must be increased by the charges for delivery to calculate the cost to the consumer at the point of use. In the areas studied this could vary from about 50¢ per tonne to about $3.00 per tonne, averaging about $1.80.

4.1.4 The Future

To predict the likely changes in the industry to the year 2000 it may help to look back 20 or 30 years, and see what has happened in that time.

Average plant sizes have increased considerably. Where once a through-put of 400 tonnes per hour was

considered a large operation, capacities of up to 1500 tonnes per hour are now common. These may be expected to continue to grow.

Equipment has increased dramatically in size. Quarry trucks have changed from 12-15 tonne capacity to 50-75. In some open-pit copper and iron mines, trucks of 200 tonne sizes are now in operation, and their use is expected to spread to the aggregate industry. Small crawler shovels of 1 to 4 cu. yards capacity have been replaced by units of up to 8 cu. yards, or by rubber tired front-end loaders up to 10 or 12 cu. yards. There are now 24 cu. yard units available. These are utilized to work with the larger haul units.

The integration of small aggregate producing operations into larger organizations is likely to continue. While there will be a significant and valuable role for the smaller operator in serving local markets, the trend is certainly to larger plants financed by large corporations.

However, beyond a general trend to continuing growth in sizes of organizations, plants, and equipment, there is no basic change on the horizon in the procedures for extracting and processing mineral aggregates. The industry is well served by manufacturers producing reliable equipment, capable of performing the required operations to produce high quality products. The larger sizes of equipment necessary for handling the predicted continued growth in hourly capacities are either already in production or in the planning stage. Technically, there is nothing lacking now to prevent the projected growth.

All this requires a continued supply of energy. A fixed plant is largely operated by electrical energy, and it is probably safe to predict that ample electrical power will continue to be available. However, nearly all the necessary mobile equipment is diesel-powered and the shortage of petroleum products would be very difficult to overcome. The rockdrills and primary excavators could be powered with electricity, as indeed some are now. Haulage from the face to the plant could revert to rail-haul, as it once used to be, but this time with electric trolley powering rather than steam or diesel. These are factors that must be kept in mind as the energy problems of the country unfold. It is probably safe to say that real energy shortages would rather reduce the aggregate producer's production problems than increase them by reducing the uses for his materials in a severely constrained economy.

4.2 PRESENT SUPPLY OF AGGREGATES AND LICENSED RESERVES IN THE FOUR DEMAND AREAS

A survey was conducted in order to obtain information on the supply of aggregates to the four demand areas.

A questionnaire was sent to 86 aggregate producers in the demand areas, as well as in surrounding areas. (All were members of the Aggregate Producers' Association of Ontario.) No questionnaires were sent to producers in areas from which aggregate movement into the four demand areas was deemed unlikely.

Replies were obtained from 48 producers, including most of the large producers. The amounts of aggregate accounted for in these replies equalled 70% of the aggregate volume consumed in the four demand areas.

Of the 38 producers who did not reply 13 were outside the demand areas and probably did not ship any amounts into the areas. Most of the remaining 25 producers were relatively small, and their production

EXHIBIT 4–1
SUPPLY AND CONSUMPTION OF AGGREGATES – 1977, TORONTO AREA

(million tonnes)

	AGGREGATE SHIPMENTS TO:					
	METRO	HALTON	PEEL	YORK	DURHAM	TOTAL
FROM:						
Metro	—	—	—	—	—	—
Halton	2.9	1.8	2.6	0.8	0.3	8.4
Peel	0.6	0.1	5.5	0.4	—	6.6
York	1.4	0.2	0.4	3.4	0.2	5.6
Durham	2.1	—	—	1.3	2.9	6.3
Simcoe (by truck)	—	—	—	0.1	0.4	0.5
Victoria	0.9	—	—	—	—	0.9
Dufferin	0.2	—	0.6	—	—	0.8
Wellington	0.4	0.4	0.2	—	—	1.0
Hamilton–Wentworth	0.1	—	—	—	—	0.1
Additional rail shipments and cement	1.3	0.1	0.4	0.4	0.3	2.5
TOTAL	9.9	2.6	9.7	6.5	4.0	32.7

was taken into consideration by factoring up the amounts reported.

Exhibits 4-1 through 4-3 show the results of the survey regarding production and consumption in the demand areas. All data requested in the questionnaires and shown in the Exhibits are for the calendar year of 1977. For each area, total 1977 production figures were provided by the Ministry of Natural Resources.

The volumes reported by the respondents were factored up to the total Ministry production data for each county and region.

It was found that practically all the aggregate produced within the demand areas stays in the areas with the exception of cement and lime which are secondary aggregate products and are only partially consumed within the areas. The Toronto area receives some of its aggregate supply from outside the area.

Toronto

Exhibits 4-1 and 4-2 show the supply and consumption of aggregates within the Toronto demand area by subarea.

The estimated reserves at the existing production sites that are presently licensed for extraction are shown in Exhibit 4-4. Since it was found that in 1977, the aggregate volumes shipped into the Toronto area from outside the area, amounted to 22% of the volumes produced inside, it was assumed that the total licensed reserves available for use in the Toronto area will also be 1.22 times the licensed reserves located within the area. When this assumption was checked against the actual reserves reported for the surrounding areas, it was found that these areas actually do have reserves at least proportional to those inside the area and should therefore be able to continue to supply the present portion of the requirements.

EXHIBIT 4–2
COARSE AND FINE AGGREGATES – 1977, TORONTO AREA

(million tonnes)

		SHIPMENTS TO:			
		WEST (Halton, Peel)	METRO	EAST AND NORTH (Durham, York)	TOTAL
FROM WEST: (Halton, Peel, Dufferin, Wellington, Hamilton)	COARSE:	5.2	2.8	0.7	8.7
	FINE:	6.1	1.4	0.7	8.2
FROM EAST AND NORTH: (Durham, York, Simcoe, Victoria)	COARSE:	—	1.4	3.2	4.6
	FINE:	0.5	3.1	5.1	8.7
		11.8	8.7	9.7	30.2

NOTE: Long-distance rail shipments and cement excluded.
Coarse/Fine ratio above. 44/56%
Coarse/Fine ratio including long-distance rail shipments: 46/54%

EXHIBIT 4–3
SUPPLY AND CONSUMPTION OF AGGREGATES – 1977

(thousand tonnes)

AREA	PRODUCTION	SHIPMENTS INTO AREA	ESTIMATED SHIPMENTS OUT FROM AREA	CONSUMPTION	COARSE/FINE RATIO
					%
Toronto	26,900	5,800	—	32,700	46/54
London	6,300	—	800(1)	5,500	45/55
Windsor	2,300	700	—	3,000	45/55
Sarnia	1,000	1,100	—	2,100	44/56

NOTE: Excludes aggregates in cement and lime shipped out from areas.
(1) Obtained from reconciliation of production and estimated consumption.

EXHIBIT 4-4
TORONTO AREA LICENSED AGGREGATE RESERVES

(million tonnes)

	COARSE	FINE	TOTAL
Halton	225	88	313
Peel	100	191	291
York	31	81	112
Durham	58	153	211
	414	513	927
Outside Area[1]	91	113	204[2]
TOTAL	505	626	1131
	(45%)	(55%)	(100%)

[1] 1977 shipments within area: 26.9 million tonnes
From outside to inside area: 5.8 = 0.22 x 26.9 million tonnes
[2] Estimated reserves available for Toronto
from outside of area: 0.22 x 927 = 204 million tonnes

A comparison of cumulative demand and supply for the Toronto area is shown in Exhibit 4-5. It appears that the *licensed reserves of 1100 million tonnes will be exhausted around the year 2000.* Approximately 10 years earlier, around 1990, alternate supply methods may become justified. At that point, about one half of the presently licensed reserves will have been consumed.

London

Exhibit 4-6 shows the estimated licensed reserves for the London, Windsor and Sarnia areas.

As shown in Exhibit 4-7, it would appear that *the supply of aggregates from the present sites in the London demand area will run out in the early 1990's.*

Windsor

The Windsor demand area presently imports 30% of its coarse aggregate requirements from the United States. As indicated in Exhibit 4-6, *a potential long-term local supply of stone, at present not sold commercially, is available on industrial property.* Presently fine aggregates are in short supply and therefore some are imported from the United States.

Sarnia

The Sarnia demand area is *already deficient in coarse aggregates* and therefore imports almost all of its requirements from the United States. Fine aggregates are also imported from the United States to supply part of the market. *Local licensed sand reserves are expected to last, at current production levels, until the early 1990's,* as shown in Exhibit 4-9.

4.3 IMPACTS OF CONTINUING THE EXPANSION OF AGGREGATE PRODUCTION IN THE DEMAND AREAS

The previous Section described the available licensed reserves in the four demand areas if no new sites were

EXHIBIT 4-5
CUMULATIVE AGGREGATE CONSUMPTION, TORONTO AREA

(million tonnes)

	ANNUAL DEMAND		CUMULATIVE CONSUMPTION	
YEAR	COARSE	FINE	COARSE	FINE
1978	15	17	15	17
1979	16	18	31	35
1980	17	19	48	54
1981	17	19	65	73
1982	17	20	82	93
1983	17	20	99	113
1984	17	20	116	133
1985	17	21	133	154
1986	18	21	151	175
1987	18	22	169	197
1988	18	22	187	219
1989	18	22	205	241
1990	19	22	224	263
1991	19	23	243	286
1992	19	23	262	309
1993	20	23	282	332
1994	20	24	302	356
1995	20	24	322	378
1996	21	24	343	402
1997	21	25	364	427
1998	22	25	386	452
1999	22	26	408	478
2000	23	26	431	504
2001	24	27	455	531
2002	25	28	480	559
2003	26	29	506*	588
2004	27	30	533	618*
2005	28	31	561	649

*Equals licensed reserves

EXHIBIT 4-6
LICENSED AGGREGATE RESERVES, LONDON, WINDSOR, SARNIA

(million tonnes)

	COARSE	FINE	TOTAL
LONDON AREA	41	59	100
WINDSOR AREA[2]	177[2]	59	236
SARNIA AREA[1]	—	18	18

[1] Available at existing production sites.
[2] Includes potential supplies of stone presently not sold commercially.

licensed, and the impacts of such restrictions in terms of dwindling aggregate supplies in the not too distant future. This Section describes the impacts of expanding the production of aggregates by granting new licenses in the areas.

In the past it has been the practice to allow continuing expansion of aggregate production in each of the four demand areas. New sites were licensed adjacent to existing pits or quarries or elsewhere in the areas, as the material at existing sites was depleted. This licensing process has been the focus of the opposing views of the producer applying for a license, and locally affected residents who oppose the granting of the license.

Toronto

Continuing the past supply conditions in the Toronto demand area without any change, other than some shift in the location of production sites, would have the following effects:

1) *Supply Sources:*
   Aggregates would continue to be extracted at the present or adjacent locations in major supply areas including:
   - Town of Caledon
   - Town of Halton Hills
   - Town of Milton
   - Township of Brock
   - Township of Uxbridge
   - Town of Whitchurch-Stouffville

2) *Aggregate Prices:*
   The prices of aggregates would increase as transportation and fuel costs increased and the distance of new sources also gradually increased.

EXHIBIT 4-7
CUMULATIVE AGGREGATE CONSUMPTION, LONDON AREA

(million tonnes)

	ANNUAL DEMAND		CUMULATIVE CONSUMPTION	
YEAR	COARSE	FINE	COARSE	FINE
1978	2.5	3.0	2.5	3.0
1979	2.6	3.1	5.1	6.1
1980	2.6	3.1	7.7	9.2
1981	2.6	3.1	10.3	12.3
1982	2.6	3.0	12.9	15.3
1983	2.6	3.0	15.5	18.3
1984	2.5	3.0	18.0	21.3
1985	2.5	3.0	20.5	24.3
1986	2.5	3.1	23.0	27.4
1987	2.6	3.1	25.6	30.5
1988	2.6	3.2	28.2	33.7
1989	2.7	3.2	30.9	36.9
1990	2.7	3.3	33.6	40.2
1991	2.8	3.3	36.4	43.5
1992	2.8	3.4	39.2 *	46.9
1993	2.9	3.4	42.1	50.3
1994	2.9	3.5	45.0	53.8
1995	2.9	3.6	47.9	57.4*
1996	3.0	3.7	50.9	61.1
1997	3.0	3.8	53.9	64.9
1998	3.1	3.9	57.0	68.8
1999	3.1	4.0	60.1	72.8
2000	3.2	4.1	63.3	76.9

*Equals licensed reserves

EXHIBIT 4-8
CUMULATIVE AGGREGATE CONSUMPTION, WINDSOR AREA

(million tonnes)

	ANNUAL DEMAND		CUMULATIVE CONSUMPTION	
YEAR	COARSE	FINE	COARSE	FINE
1978	1.4	1.6	1.4	1.6
1979	1.5	1.7	2.9	3.3
1980	1.5	1.8	4.4	5.1
1981	1.5	1.8	5.9	6.9
1982	1.5	1.8	7.4	8.7
1983	1.5	1.8	8.9	10.5
1984	1.5	1.8	10.4	12.3
1985	1.5	1.8	11.9	14.1
1986	1.5	1.8	13.4	15.9
1987	1.5	1.8	14.9	17.7
1988	1.5	1.9	16.4	19.6
1989	1.5	1.9	17.9	21.5
1990	1.5	1.9	19.4	23.4
1991	1.6	1.9	21.0	25.3
1992	1.6	2.0	22.6	27.3
1993	1.6	2.0	24.2	29.3
1994	1.7	2.0	25.9	31.3
1995	1.7	2.0	27.6	33.3
1996	1.7	2.1	29.3	35.4
1997	1.8	2.1	31.1	37.5
1998	1.8	2.2	32.9	39.7
1999	1.8	2.3	34.7	42.0
2000	1.9	2.4	36.6	44.4

EXHIBIT 4-9
CUMULATIVE AGGREGATE CONSUMPTION, SARNIA AREA

(million tonnes)

	ANNUAL DEMAND		CUMULATIVE CONSUMPTION	
YEAR	COARSE	FINE	COARSE	FINE
1978	0.9	1.2	0.9	1.2
1979	0.9	1.1	1.8	2.3
1980	0.8	1.0	2.6	3.3
1981	0.8	1.0	3.4	4.3
1982	0.8	1.0	4.2	5.3
1983	0.8	1.0	5.0	6.3
1984	0.8	1.0	5.8	7.3
1985	0.8	1.1	6.6	8.4
1986	0.8	1.1	7.4	9.5
1987	0.8	1.1	8.6	10.6
1988	0.9	1.1	9.5	11.7
1989	0.9	1.1	10.4	12.8
1990	0.9	1.1	11.3	13.9
1991	0.9	1.2	12.2	15.1
1992	0.9	1.2	13.1	16.3
1993	1.0	1.2	14.1	17.5*
1994	1.0	1.2	15.1	18.9
1995	1.0	1.2	16.1	19.9
1996	1.0	1.3	17.1	21.2
1997	1.0	1.3	18.1	22.5
1998	1.1	1.3	19.2	23.8
1999	1.1	1.3	20.3	25.1
2000	1.1	1.4	21.4	26.5

*Equals licensed reserves

3) *Truck Traffic:*
   a) Present truck volumes on existing aggregate routes would continue or increase, such as:
      — Highway 10, Caledon: presently approximately 120 trucks per hour, two-way combined.
      — Highway 48, Markham: presently approximately 85 trucks per hour, two-way combined.
   b) The side-effects of aggregate truck traffic (e.g., noise, dust, traffic delays, perceived safety hazards) would continue, unless special measures are implemented to reduce the impacts of this traffic, such as the improvement or construction of roads for heavy aggregate traffic or other traffic improvements.

4) *Effects on the Natural Environment:*
   Conflicts between aggregate production sites and certain natural features, such as the Oak Ridges Moraine and the Niagara Escarpment, would develop. As an example, the Amabel Formation of the Niagara Escarpment is one of the most dependable sources of crushed stone available to the Toronto area. However, the Niagara Escarpment Commission has recommended that "the Escarpment not be considered a permanent source of aggregate". [1]

London

When the present supply conditions are projected in the London area, the nature of the impacts is similar to those in Toronto but their scale is smaller.

Aggregate would be supplied from the municipalities adjacent to London (Westminster, Lobo, North Dorchester, West Nissouri, and London Townships).

Truck and environmental impacts comparable to the present situation would continue.

Windsor

For the Windsor area, Michigan presently provides important sources of aggregate supplies. For example, in 1977, U.S. sources supplied approximately 40% of the area's coarse aggregate requirements, and also supplemented the local insufficient supply of fine aggregates for concrete.

However, the Windsor area would not have to import large quantities of coarse aggregates from the U.S. if an existing major local industry produced coarse material for public use. Sufficient local quantities of coarse material would then be produced, but fine material for concrete would still have to be imported from the U.S. Fine material for other uses could be available locally, though, as screenings from quarries and from local pits.

Increasing local production of coarse aggregates in the Windsor area would result in such impacts as truck traffic noise, dust, removal of agricultural land, and changes in the natural environment around the quarries, each of which could result in opposition to proposed expansions of the local operations.

Sarnia

The Sarnia area also depends on Michigan for important sources of aggregate supplies. For example, U.S. sources presently provide Sarnia with all its crushed stone, as well as its fine materials for concrete. In addition, Sarnia imports small amounts of coarse and fine aggregates from Middlesex and Huron Counties.

All or part of Sarnia's required aggregates (coarse and fine) could continue to be supplied from the United States, given the quantities of materials available there. However, the issue of security should be considered — i.e., will the U.S. continue to export aggregates in the amounts demanded by the Sarnia market?

(1) *Niagara Escarpment Commission "The proposed Plan for the Niagara Escarpment", November 1979, Section 4.15.1(c), page 65.*

Importing aggregates from the U.S. avoids the various community, agricultural, and natural environment impacts of aggregate extraction in the Sarnia area. The only potential issue of continuing this situation would be the impact of distributing the materials from the terminals to the final users, an issue that is common to practically all supply alternatives.

4.4 ESTIMATE OF AGGREGATE RESERVES UNDER ALTERNATIVE SUPPLY POLICIES

Various possible, albeit hypothetical, policies can be examined with regard to the licensing of new aggregate production sites.

The most restrictive policy, in which no new licences are issued, was examined in Section 4.2. Whereas existing operations would be allowed to continue until their reserves are used up, this policy implies a freeze on the issuing of new licences in the demand areas under consideration. It was shown in Section 4.2 that under such a policy mineral aggregate supplies would be depleted within a relatively short time in all four demand areas.

At the other extreme, a policy could be established to permit extraction at any source desired by the owner.

Between these extremes several policies could be defined that would impose varying degrees of restriction on the licensing of new aggregate production sites. To demonstrate the impact of such a range of policies four scenarios were constructed for the purpose of this study and examined in some detail.

The four policies are described in tabular form in Exhibit 4-10 and are briefly summarized below.

- *Policy 1* is the least restrictive of the four policies. It assumes approval and licensing for all sites that are located at least:
  - 30 metres from a road allowance
  - 15 metres from property boundaries, or
  - 100 metres from the natural edge of the Niagara Escarpment.
- *Policy 2* is moderately restrictive. In addition to the restrictions of Policy 1 this could allow the granting of a new licence if the distance of the site is at least:
  - 60 metres from an environmentally "significant" feature:
  - 60 metres from a natural watercourse with a top-of-bank width of more than 8 metres
  - 60 metres from a built-up area.

  Furthermore no licence would be issued for locations in the "A" and "B" areas of the preliminary draft Niagara Escarpment Plan policies and Complementary Use Area designation of the Parkway Belt.

  Also, the availability of an arterial class road would be the prerequisite for granting a new licence.
- *Policy 3* is significantly restrictive.

  The most essential feature of this policy is the denial of a licence to any production site in an area that is not designated in an approved regional (county) and local Official Plan for aggregate extraction. No Official Plan and zoning amendments for designating additional areas would be approved.

  In addition to these restrictions, setback requirements are also increased in relation to the previous policies. Accordingly, the distance of a production site for which a new licence may be issued must be at least:
  - 150 metres from an environmentally "sensitive" feature:
  - 150 metres from a natural watercourse with a top-of-bank width of more than 8 metres
  - 150 metres from a built-up area.

  Also, no aggregate extraction would be permitted where Class 1 and 2 soil capability [1] for agriculture constitutes more than 50% of the area proposed for licensing.
- *Policy 4* is the most restrictive. It is identical to the policy assumed in Section 4.2, i.e., no licence is granted to any new production site, but existing sites are allowed to operate until their reserves are depleted.

After having defined the four policy scenarios on a successively more restrictive scale, estimates were made of the available possible resources of mineral aggregate that could be extracted in each demand area under each policy.

In order to obtain a broad estimate of the possible resources, sample sub-areas were chosen within the demand area. Those sub-areas that presently contain most of the licensed aggregate reserves in the demand area were selected for the samples.

In each sample sub-area the amount of possible resources were estimated on the basis of information available from the Ministry of Natural Resources, of previously published reports, including those listed on page 2, of discussions with local producers and other information developed by the study team.

Next, the restrictions of each policy were applied to the sample sub-areas under consideration and the percentage of available total possible resources was determined that could be extracted under each policy. This percentage was then applied to the estimated possible resources of the entire demand area.

The results of these estimates are summarized in Exhibits 4-11 to 4-14. These show the estimated reserves of each demand area under successively relaxed policies.

[1] *As defined by the Canada Land Inventory.*

EXHIBIT 4–10
POLICY SCENARIOS FOR AGGREGATE EXTRACTION

COMPONENTS	RATIONALE
POLICY 1 LEAST RESTRICTIVE	
All potential source areas are licensed except:	
1. No quarrying allowed in the Amabel or Lockport Formation closer than 90 metres to the natural edge of the Niagara Escarpment.	1. Section 10(1), *Pits and Quarries Control Act,* 1971.
2. No aggregate extraction allowed within 30 metres of a road allowance, 15 metres of any other property boundary.	2. O/Reg. 545/71, Section 14.
3. All municipal planning approvals are obtained.	3. Municipalities can pass by-laws under Section 35(1) of the *Planning Act* prohibiting the establishment of a pit or quarry.
POLICY 2 MODERATELY RESTRICTIVE	
All potential source areas are licensed except:	
1. Areas restricted by Policy 1.	1. Restrictions are cumulative.
2. No new aggregate extraction permitted in the "A" and "B" areas of the preliminary draft Niagara Escarpment Plan Policies.	2. Preliminary Draft Niagara Escarpment Plan Policies, April 1979.
3. No new aggregate extraction permitted in the Complementary Use Area designation of the Parkway Belt.	3. Parkway Belt West, June 1979.
4. No aggregate extraction permitted within 60 metres of an environmentally significant feature.	4. The Minister has the discretion to refuse a licence after considering "the preservation of the character of the environment". Section 6(1), Pits and Quarries Control Act, 1971. Neither the 1971 Act, the *Aggregates Act, 1979* nor O/Reg. 545/71 establish setbacks from environmental features. A figure of 60 metres is used as a moderate restriction.
5. No aggregate extraction permitted within 60 metres of a natural watercourse which has a top-of-bank width of more than 8 metres.	5. See rationale for Item 3 above. The Minister can refuse to issue a licence after considering "the possible effect on the water table or surface drainage pattern", Section 6(1), *Pits and Quarries Control Act,* 1971.
6. No aggregate extraction permitted within 60 metres of an urban/hamlet/built-up area.	6. The Minister can refuse to issue a licence after considering "the character, location and size of nearby communities", Section 6(1), Pits and Quarries Control Act, 1971. The figure of 60 metres is used to provide a buffer for noise and dust.
7. An arterial class road is available or can be provided.	7. An arterial class road is necessary to accommodate traffic flows within the source areas.

The following comments are made in relation to the results shown in Exhibits 4-11 to 4-14:

Exhibit 4-11: Toronto

- The decline in possible resources from Policy 1 to Policy 2 results from the application of Proposed Niagara Escarpment Plan Policies (that is, extraction generally permitted only in existing licensed areas).
- The decline in possible resources from Policy 2 to Policy 3 largely results from the application of Official Plan policies (the potential resource areas are not designated for extraction) and the restriction on agricultural land.

EXHIBIT 4–10 (continued)
POLICY SCENARIOS FOR AGGREGATE EXTRACTION

COMPONENTS	RATIONALE
POLICY 3 SIGNIFICANTLY RESTRICTIVE	
1. Areas restricted by Policies 1 and 2 with increased setback figures: – no aggregate extraction permitted within 150 metres of an environmentally sensitive feature – no aggregate extraction permitted within 150 metres of a natural watercourse – no aggregate extraction permitted within 150 metres of an urban/hamlet/built-up area – no aggregate extraction permitted where Class 1 and 2 soil capability for agriculture constitutes more than 50%.	1. Restrictions are cumulative – see rationale for Item 3, Policy 2. Increased setback is a greater restriction – see rationale for Item 4, Policy 2. Increased setback is a greater restriction – see rationale for Item 5, Policy 2. Increased setback is a greater restriction – Class 1 and 2 land is assumed to have a higher priority than aggregate extraction.
2. Only source areas which are designated in approved and draft regional (county) and local Official Plans for extraction are licensed. Any necessary municipal approvals are obtained.	2. Municipalities can pass by-laws under Section 35(1) of the *Planning Act* prohibiting the establishment of a pit or quarry. Some Official Plans have not designated as "permitted" all existing pits and quarries and known potential aggregate sources.
3. Source areas with specific exemption policies in Official Plans (recognition of existing licensed pits outside areas designated for extraction) continue to operate. Any necessary municipal approvals are obtained.	3. Some Official Plans provide exemptions for existing operations.
4. No Official Plan and rezoning amendments to designate additional source areas are approved.	4. Future extraction operations will be limited.
POLICY 4 MAXIMUM RESTRICTIVE	
1. No expansion of aggregate extraction beyond the extent of existing licences. 2. No new licences issued.	1-2. No further areas of aggregate extraction will be permitted.

Exhibit 4-12: London

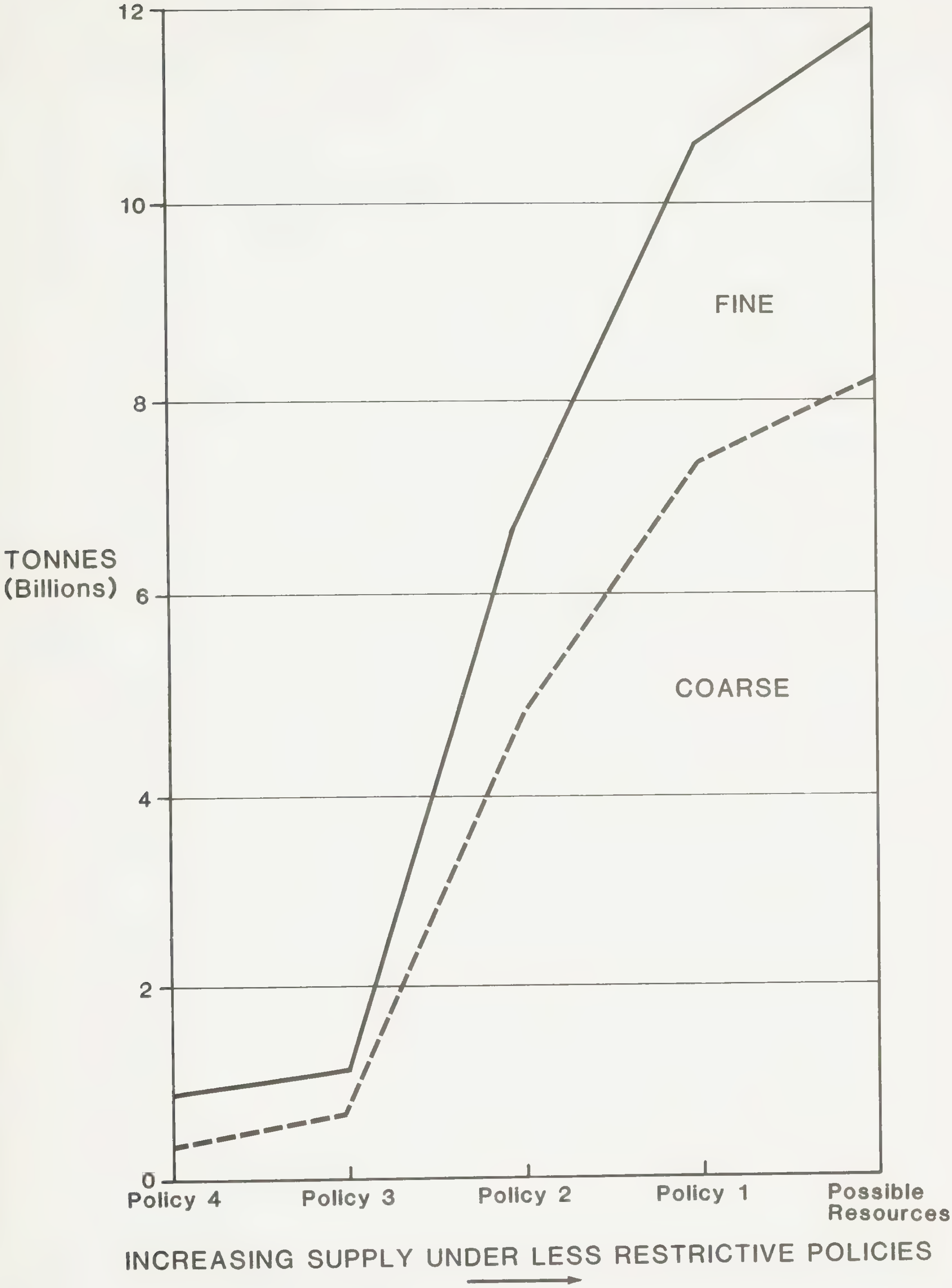
- The decline in possible resources from Policy 2 to Policy 3 largely results from the application of official plan policies (the potential resource areas are not designated for extraction) and the restriction on use of Class 1 and 2 lands.

Exhibit 4-13: Windsor

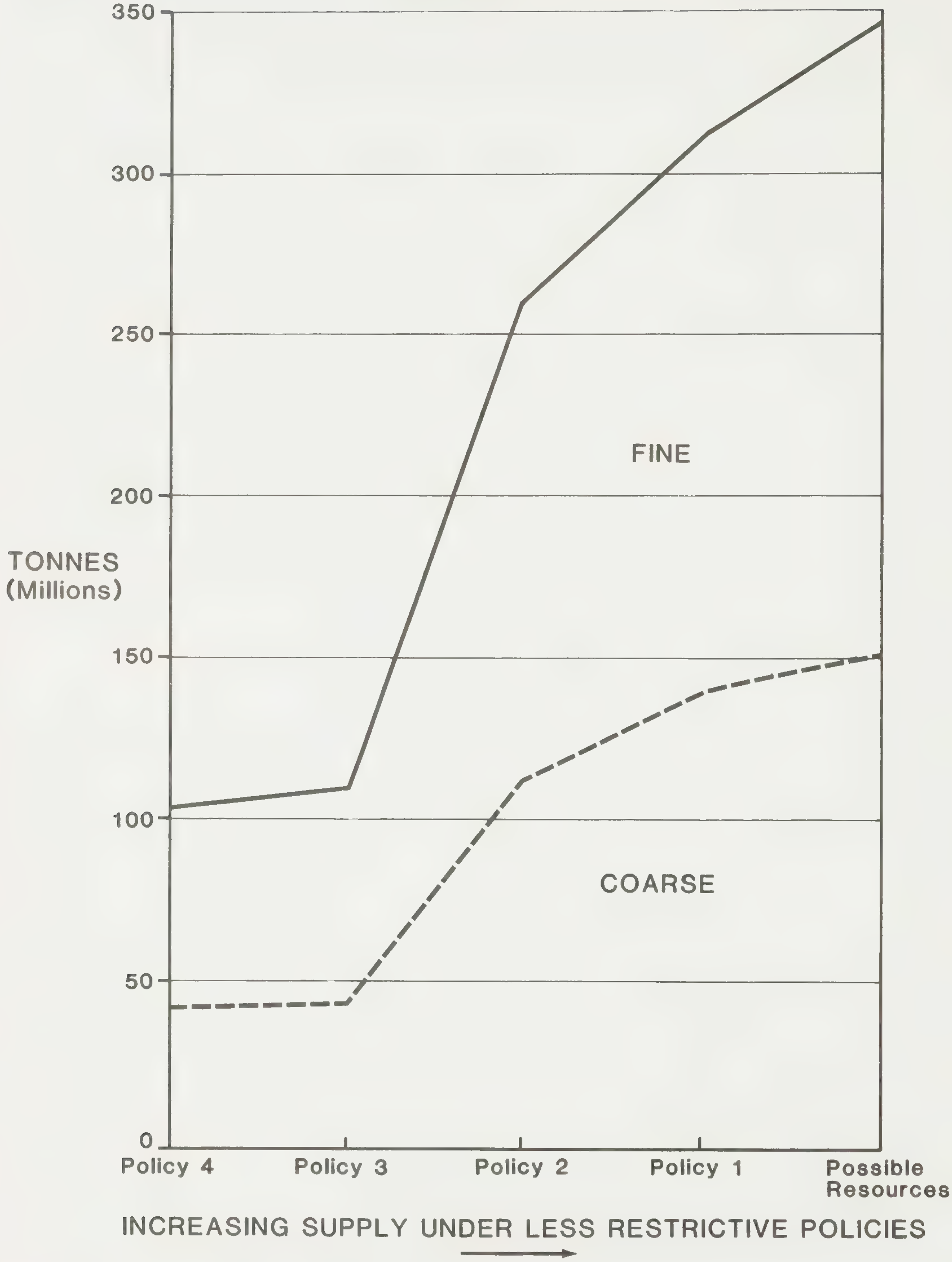
- The decline in potential reserves from Policy 2 to Policy 3 largely results from the application of the restriction on Class I and 2 lands.

Exhibit 4-14: Sarnia

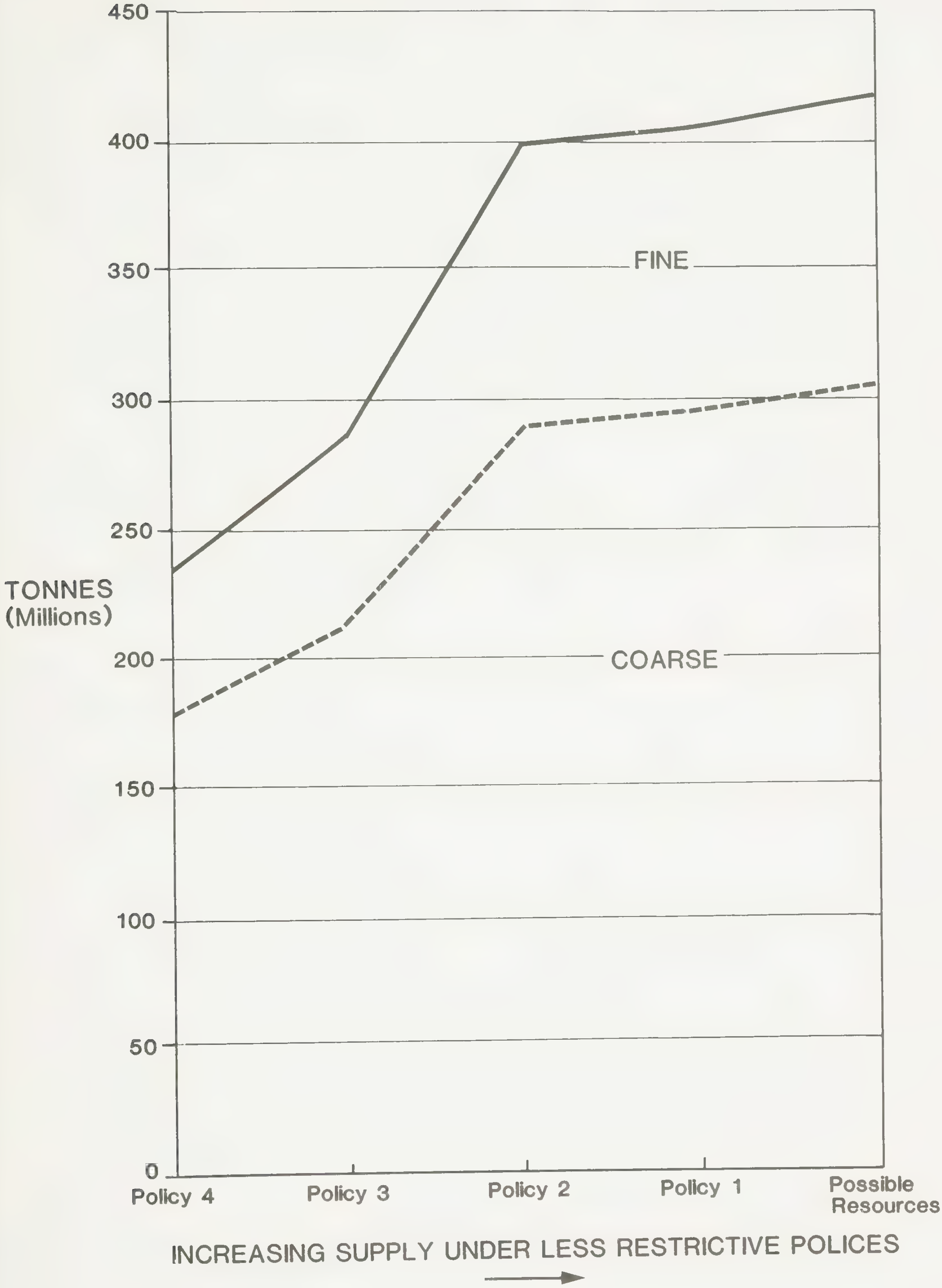
- The decline in potential reserves from Policy 1 to Policy 3 results from the restriction on residential areas (existing built-up areas and areas designated for future urban development).



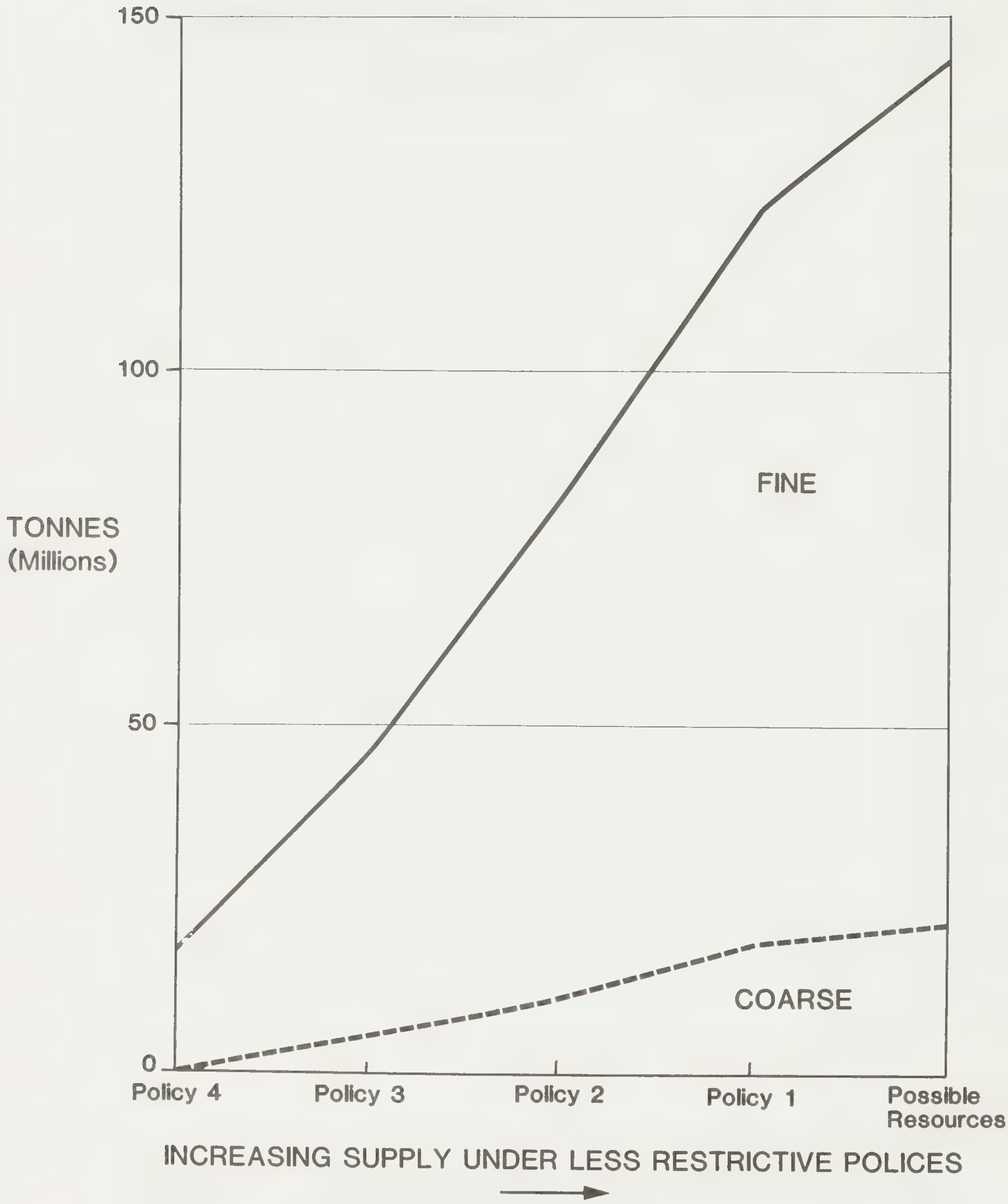
POSSIBLE RESOURCES - TORONTO AREA **4-11**



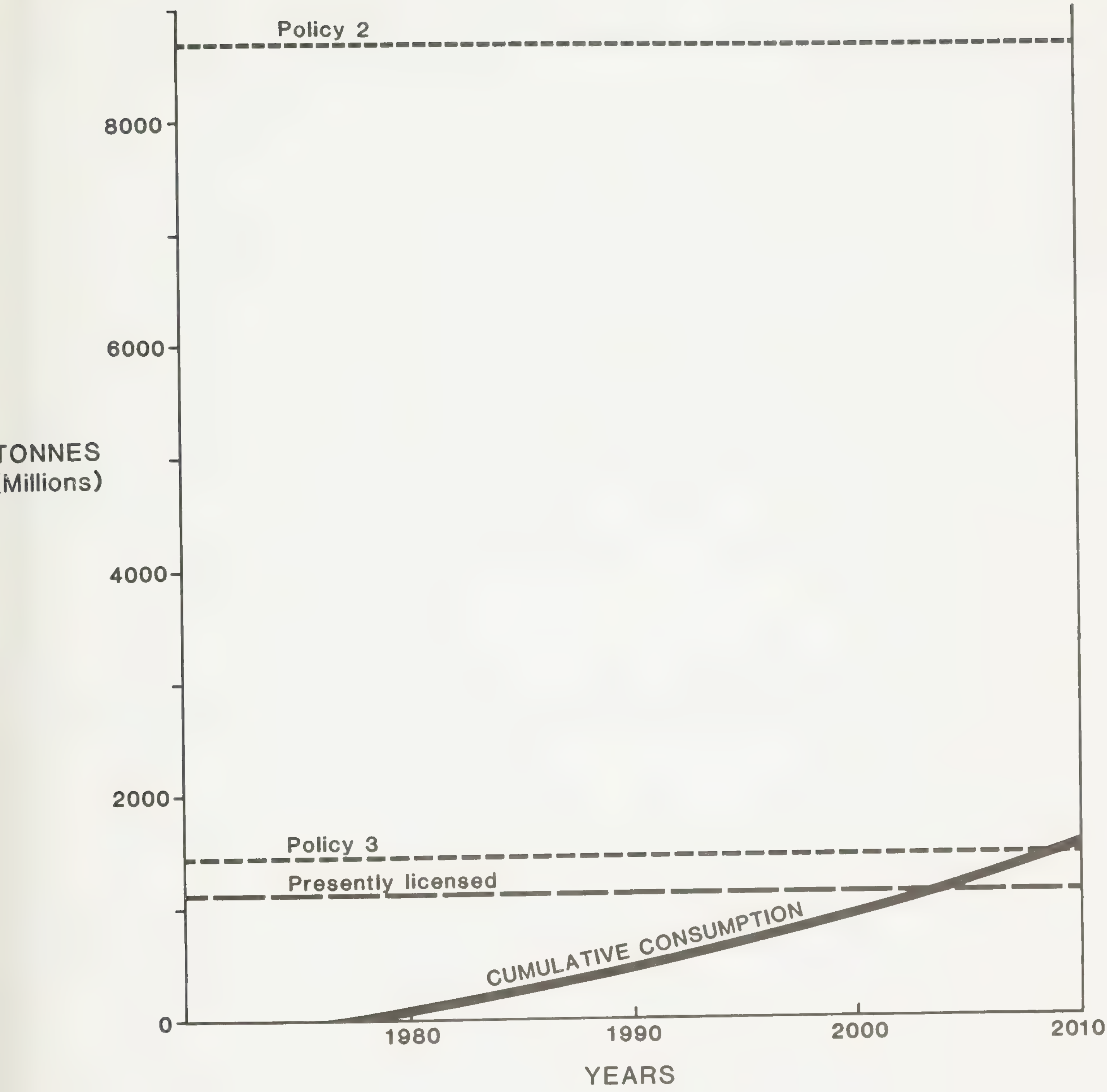
POSSIBLE RESOURCES - LONDON AREA 4-12



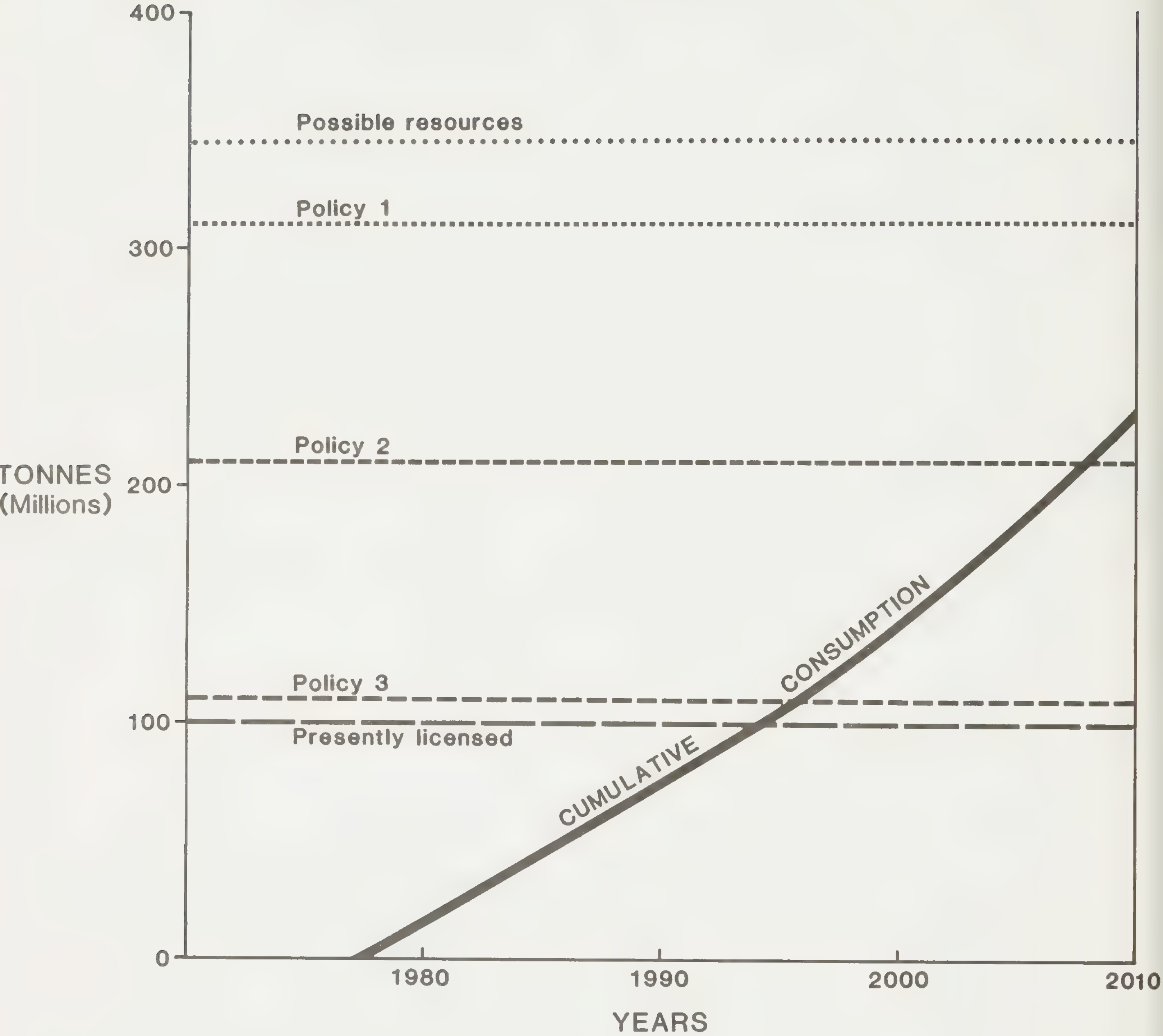
POSSIBLE RESOURCES - WINDSOR AREA **4-13**



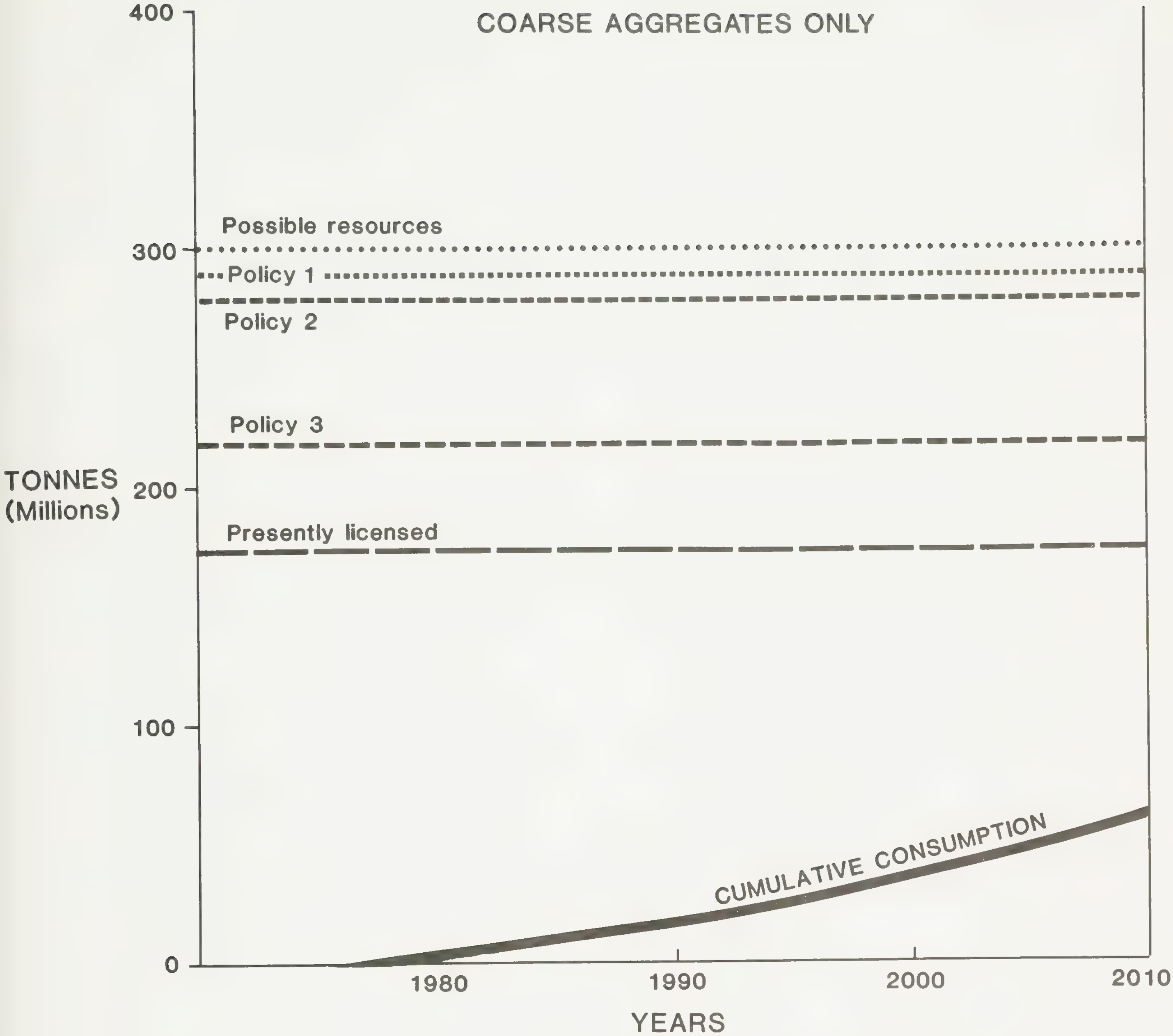
POSSIBLE RESOURCES - SARNIA AREA **4-14**



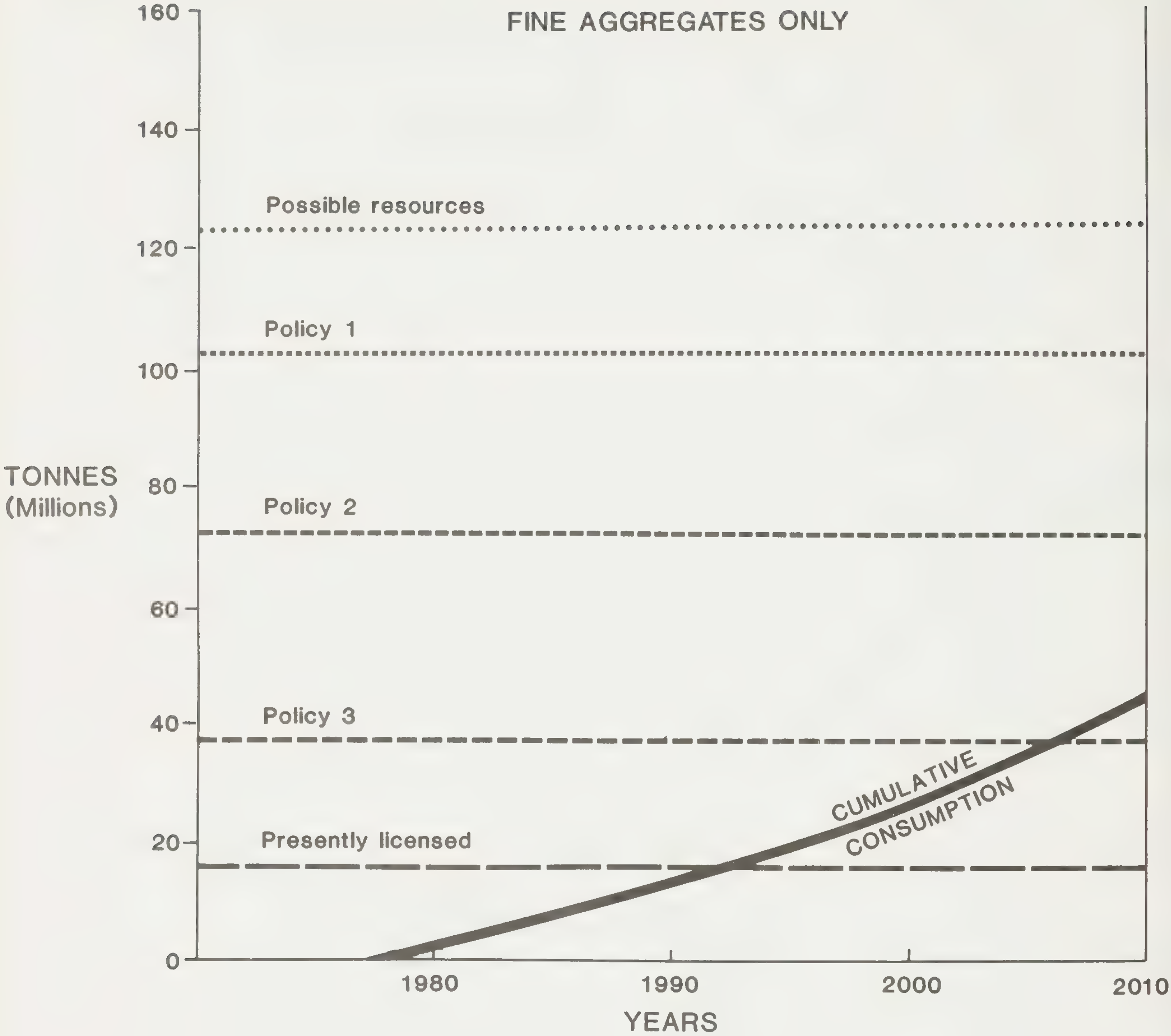
SUPPLY AND CONSUMPTION - TORONTO AREA 4-15



SUPPLY AND CONSUMPTION - LONDON AREA 4-16



SUPPLY AND CONSUMPTION - WINDSOR AREA 4-17



SUPPLY AND CONSUMPTION - SARNIA AREA 4-18

4.5 RELATIONSHIP BETWEEN POSSIBLE AGGREGATE RESOURCES AND DEMAND UNDER ALTERNATIVE SUPPLY POLICIES

The future demand for aggregates in each area was identified in Exhibits 4-5 to 4-9. These demand figures are compared in Exhibits 4-15 to 4-18 to the possible resources available under each of the policies shown in Exhibits 4-11 to 4-14. The forecasts correspond to the "continuing growth" projection.

Toronto (Exhibit 4-15):

- Ample possible resources of coarse and fine material are available beyond 2000 under Policies 1 and 2. Under Policies 3 and 4 approximately one half of the possible resources would be consumed in the early 1990's. Under Policies 3 and 4 the possible coarse and fine resources would be completely consumed around 2000.
- Alternative sources for aggregate will be required if policy restrictions such as those in Policies 3 or 4 are placed on aggregate extraction.

London (Exhibit 4-16):

- Ample possible resources of coarse and fine material are available under Policy 1.
- Under Policy 2, approximately one half of the possible coarse resources would be consumed by 1990 and one half of the fine resources would be consumed by 2000.
- Under Policy 3 and 4, approximately one half of the possible coarse and fine resources will be consumed by the mid-1980's, and all possible resources would be depleted by the early 1990's.
- Alternative sources of coarse and fine materials will be required if policies do not allow the extraction of possible resources.

Windsor (Exhibit 4-17):

- Adequate possible resources of coarse material are available to meet the demand to 2000 even under the most restrictive policy if an existing local industry were to provide aggregate for public sale.
- If this industry did not make coarse material available, alternative sources must be provided.
- Possible resources of fine material are estimated to be insufficient. In the 1990's most local fine material would result from stone crushing which does not provide sufficient supplies of fine material.
- Alternative sources, such as continuing supply from the U.S. or long distance transportation will be required for fine materials.

Sarnia (Exhibit 4-18):

- There are insufficient possible resources of coarse material available under any policy.
- A large possible resource of fine material is available under the least restrictive policy. However, the fine material is only suitable for a limited range of uses and must be supplemented by higher quality material from outside the area.
- Alternatives, such as continuing supply from the U.S. or long distance transportation from Ontario sources, will be required for both coarse and fine materials.

CHAPTER 5
New Sources of Supply

Several potential source areas may be considered for future production of mineral aggregates in Ontario. Extraction at these locations has so far not been developed at a significant scale because of the relatively long distance from the areas to the major markets. The Terms of Reference of this study specified two such areas for consideration:

- one area in Grey, Bruce, and Huron Counties hereafter referred to as the "Saugeen Area" where 1arge deposits of sand and gravel are known to exist
- Manitoulin Island where widespread exposures of dolostone and limestone merit consideration for the development of major quarries.

The location of these areas is shown in Exhibit 1-1 of Chapter 1.

5.1 THE SAUGEEN AREA

The Ministry of Natural Resources specified 10 potential sites for consideration, located in 10 townships. These sites varied in size from 1,600 acres to 35,000 acres. The Ministry provided maps showing the outlines of the deposits, estimates of the quality and quantity of the material present, stone/sand ratios, and depths of deposits. This information was supplemented by subsequent field investigations of all readily accessible pits and road cuts, and by discussions with producers familiar with the areas in question.

In analyzing the suitability of the sites, initial consideration was given to the following factors:

- *Depth of Deposit.* Sites which averaged less than 6 metres in estimated depth were discarded. While shallower deposits may be suitable for local supply, they do not lend themselves to the large-scale operations required for the purposes of this study.
- *Stone/Sand Ratios.* A proportion of at least 45% stone was sought, to match the indicated market demand. Areas lower in stone content were eliminated from first consideration, but were identified as secondary sources, should requirements for higher ratios of fine aggregates arise.
- *Quality of Material.* Some areas showed the presence of troublesome amounts of chert and/or siltstone. In others, the sand appeared excessively fine and dirty. These problems would not be insurmountable, but caused certain sites to be rejected as better materials were available elsewhere.

After a thorough assessment, only four of the sites were felt to be primarily suitable for the large-scale development envisaged in this study, subject to review under other criteria. Two of these four sites are contiguous in one part of the area and the other two are contiguous at some distance from the first pair. These sub-areas have been called North Saugeen and Southwest Saugeen in the study.

The North Saugeen sub-area was estimated to have possible resources of about 850 million tonnes of material (averaging 50% coarse and 50% fine content), after locations considered to be environmentally unacceptable for development were eliminated. The material is situated in many separate deposits, on approximately 13,000 acres. In Southwest Saugeen, about 160 million tonnes of material were indicated, with a 50/50% coarse/fine ratio, on about 3000 acres.

A third area, Southeast Saugeen, has possible resources approximately equal to those of North Saugeen but the quality is poorer due to high sand content. However, if mixed with stone produced from underground mines in the market areas this material could be used, thus almost doubling the possible resources of the Saugeen area.

If deliveries from the Saugeen sites to the various markets were to be made by rail, the two source areas could be developed in one of the following ways:

(i) *Centralized Processing and Shipping.* Large shipping terminals for each area, with a large aggregate processing plant located alongside each terminal, with raw pit-run delivered from the excavation sites by truck or conveyor.

(ii) *Decentralized Processing, Centralized Shipping.* Large shipping terminals for each area, with small to medium-sized processing plants strategically located at major deposits within the area, delivering their products to the terminals by truck.

(iii) *Decentralized Processing and Shipping.* Several small to medium-sized processing plants located at the major deposits within the area, with direct rail service from each plant.

For development to be feasible, deposits must be sufficiently large to permit an economic life of at least 20 years per plant. While the two source areas contain substantial quantities in total, they are made up of many separate deposits, and much of the total tonnage available may not be recovered through a series of small plants as economically as through a large centralized facility. This would make Alternative (i) more attractive than the others.

Another important consideration is the uniformity of the product. Many small producers delivering to a large common terminal could not guarantee the degree of product uniformity that certain customers would require. Thus, small individual production plants could only ship their products directly to their customers and not through common facilities. This consideration eliminates Alternative (ii).

It was therefore envisaged early in the study that the first alternative would be the most economical method of developing the Saugeen area. However, the economics of Alternative (iii), consisting of direct shipments to customers, was also evaluated to confirm the preliminary assessment.

Under Alternative (i), large rail terminals would be constructed with large aggregate processing plants directly connected to the terminals. Raw material would be fed to the processing plants by truck or conveyor, and blending would be carried out at or before the primary crusher. Thus, material from many different excavation sites would produce a range of products at each loading point, and all available deposits could be extracted, regardless of their size, providing the maximum recovery from each source area and hence the maximum benefit from the large investments involved. The average haul to the plan in each area would be about 5-10 kilometres, depending on plant size.

Under Alternative (iii), where direct shipments would be made from the processing plants to the customers, small to medium-sized plants might be located throughout the source areas at locations that would provide adequate supplies for a reasonable operating life. This would closely parallel the present style of activity within the aggregate industry.

The impact of each type of development on the local communities would be rather different, however, and this was considered after the evaluations.

In general, the operating conditions throughout the Saugeen area would be very similar to those at the sites now supplying sand and gravel for the demand areas considered. Depths of overburden and of the granular deposits themselves are typical of many existing Ontario production locations. The production season available for washing operations may be shorter by a week or two than at the southerly points. Generally, though, it can be assumed that the average selling price prevailing at the present sources would be adequate for the Saugeen sources if new plants could be built at a capital cost similar to that of existing plants. Because of high inflation in capital expenses, however, the cost of aggregates at the new plants would be higher, and this was considered in the economic evaluations.

5.2 MANITOULIN ISLAND

There are presently no commercial quarrying operations on Manitoulin Island although some are in the construction or planning stage. There is little doubt that from the very large areas of dolostones and limestones available on the Island extensive deposits of satisfactory material would be indicated at several locations by detailed surface examination and drilling. Only sites favourably located within a short distance of existing or possible transportation routes could be competitive. C.P. Rail, which services Little Current across the La Cloche Island connection, offers an outlet, as do those locations on the Lake Huron and North Channel shorelines where water depths in excess of 10 metres and access to a sheltered location would permit the development of shiploading facilities. Unfortunately much of the shoreline is shallow and quite exposed, particularly along the south side of the Island. To avoid added costs, the quarry sites should be as close to the shipping point as possible, and investigations of possible sites should probably be confined to locations within at most 5 kilometres of the port site.

Operating conditions on Manitoulin Island would generally be comparable to those prevailing at presently operating quarries in southern Ontario, except for a somewhat harsher climate and, initially at least, the probable lack of an experienced labour supply. Total labour availability should be good, though, as there is a high rate of unemployment at present in the area. Note that for water shipment, loading is confined to the 8-month season from mid-April to mid-December, and unless extensive stockpiling facilities are provided, a crushing plant's operating season would not be more than 9 months.

The price of stone products from quarrying operations on Manitoulin Island should not be much different from the price charged by existing operations near the demand areas under consideration. These prices have therefore been used as the basis for the economic evaluations, subject to inflationary increases.

5.3 UNDERGROUND MINING

Frequent suggestions have been made to review the possibility of producing stone from underground operations. This could provide required materials without greatly disturbing the surface conditions, and if mines were located near the markets, the costs and problems related to transportation could be significantly reduced.

Several limestone mines are operating in the United States at various locations. They are of two general types:

- excavation of the horizontal projection of a surface quarry where the valuable stone continues under excessive overburden or where development from the surface is otherwise rendered impossible.
- opening of a deep-seated layer of stone by a vertical or inclined shaft where the desired material does not appear at or near the surface so as to permit normal quarrying.

A notable example of the former situation occurs in Kansas City where a horizontal layer of limestone 4 to 5 metres high is entered from an old quarry face. Here the worked-out underground space has been devel-

oped for use as a storage area for various commodities and for offices, factories, and laboratories. However, special conditions of access, competent floor and back formations in the excavated areas, freedom from underground water seepage, and lack of competition from other aggregate sources have made this development feasible. Such conditions do not occur often. No such conditions are known to exist within any of the study areas in Ontario.

The second type of operation — opening a desirable layer of stone underground by a shaft — could be possible in each of the four market areas under review.

The Bobcaygon and Gull River limestones, which underlie the Toronto area at about 400 metres, are well known from extensive quarrying where they are found at the surface: between the Orillia and Kingston areas excellent material is produced. However, it is risky to assume that the quality of the formation remains constant as it extends from a known source out over a widespread distance.

At Windsor, Sarnia, and London, the quality of the material which might be available is largely unproven and its suitability for various aggregate purposes is uncertain. In each area, detailed drilling and testing would be necessary to confirm the presence of suitable material on which a substantial investment for the development of an underground source could be based.

If underground mining were undertaken, it is probable that the blasted stone would be reduced to about a 20 cm size by a primary crusher located underground. The stone would then be hoisted to bins at the shafthead. Here the product would be equivalent to that from a conventional quarrying operation and the subsequent finer crushing, sizing, stockpiling, and shipment would in each case involve the same processes and equipment. Thus, in comparing the costs of underground and surface operations, the only items that should be considered are those pertaining to the processes before the secondary crushers in a surface quarry and before the ore bins at the shafthouse of an underground mine.

Installations capable of producing up to 5 million tonnes per year from depths of 100, 200, and 400 metres were analyzed and compared with typical surface operations of the same capacity.

It must be realized, however, that only stone can be produced from underground operations, most of which consists of coarse aggregate and therefore additional fine aggregates would have to be provided by other means.

The economics of underground mining as an alternative source are discussed in Chapter 8 and compared with the costs of supply from other sources.

5.4 DREDGED LAKE-BOTTOM MATERIAL

It has been suggested that a supply of aggregates could be obtained from dredging the Great Lakes. This has been done in fact for many years, and at one time several Canadian self-unloading sand-sucker vessels were engaged in the trade. Only one ship is left working now in the study area, the others having been scrapped due to obsolescence and high costs. Several operations exist, however, on the U.S.A. side of the lakes.

Such vessels can work in waters up to about 25 metres deep, pumping material sucked from the lake bottom into their holds. They then proceed to their destination ports and unload onto the customers' docks on a daily cycle. In some areas, small amounts have been obtained by draglining from the shorelines or clamming into barges.

These activities are controlled by the Ministry of Natural Resources, which issues licences under the Beach Protection Act. Production for the past several years has been running at about 600,000 tonnes per year in Ontario.

The opportunities for increasing this trade are uncertain. Usually only sand is produced and its graduation cannot be adequately controlled to compete fully with the product of a good land-based plant. The material from some locations is saleable only as fill.

The possible resources of material available for extraction are possibly larger than presently proven but this is uncertain. The only real way to test a source is to dig a load and examine the product, which requires the prior approval of the Ministry. Due to the same Ministry's concern with fish stocks, and the fear that breeding areas would be endangered by dredging activities, permission for prospecting in many possibly productive locations has at times been refused. One program instigated by the Ministry a few years ago proved unsuccessful in establising a new source area.

In short, the potential for any expansion of the supply of dredged aggregates is questionable, requiring the construction of costly specialized vessels and based on an unknown life expectancy. The fact that the Ontario fleet has dwindled in size to one ship is indicative of the judgment of experienced operators as to the prospects for economical operations. A few U.S. vessels still operate on Lake Erie, but the numbers in that fleet have dropped over the years.

It must be concluded that dredging cannot be expected to provide a significant supplement to the existing supply of aggregates in any of the demand areas considered in the study.

5.5 SUBSTITUTE MATERIALS

Various suggestions have been made regarding the possible replacement of conventional mineral aggregates extracted from pits and quarries by materials derived from other sources. Such substitute materials are already being used in some locations for several types of applications. They are reviewed below.

5.5.1 Manufactured Products

The replacement of mineral aggregates by such manufactured materials as plastics or synthetics should be considered unlikely because of high costs.

5.5.2 Recovered Waste Materials

Considerable attention has been given in recent years to the possibility of substituting various waste materials for construction aggregates. An extensive literature exists on this subject.

A relevant study report was published in 1976 by the Transportation Research Board of the U.S. National Research Council (TRB): "Waste Materials as Potential Replacements for Highway Aggregates". While directed towards use in road-building, it may be taken as an informed commentary on the availability of such materials for use in general construction.

Thirty-one different waste materials were judged to merit consideration by this study. After careful analysis of mass availability, location quality, cost and environmental effects, the materials were assigned to four different classes of merits.

The report states: "Class I refers to those materials that show the most potential for use as highway aggregate. Nearly all of these materials have received some measure of acceptability for highway use. All possess the desirable properties of aggregate and all are capable of treatment. Generally, they are located in or near metropolitan areas and occur in sufficient quantity to provide a continuous source of supply for highway construction."

Six materials were found to be in this category:

Iron Blast Furnace Slag	—available in Ontario at Hamilton and Sault Ste Marie
Reclaimed Paving Material	—becoming more widespread in Ontario if specified by MTC or municipal engineering authorities
Fly Ash	—available at coal-fired power plants in Ontario
Bottom Ash	—available at coal-fired power plants in Ontario
Boiler Slag	—not available in Ontario
Anthracite Coal Refuse	—not available in Ontario

Regarding *iron blast furnace slag*, all the production at Hamilton of about 2 million tonnes is already being successfully utilized, either by the construction industry as aggregate or as raw material by the insulating wool and cement industries. The expected new production from the Nanticoke operation of Stelco — probably about 300,000 tonnes a year initially — should find similar outlets. Neither of these sources will affect the market areas under review in this study. Some of the production of slag from Algoma Steel at Sault Ste Marie might be shipped by water to Great Lakes ports, but would find close competition from several U.S. steel mills located around the Lakes.

The next three listed materials are by-products of the burning of coal, and amount to about 10% of the coal consumed by weight. In Ontario, the major coal users are the Ontario Hydro plants at Mississauga (Lakeview), Nanticoke and Sarnia. Due to the type of equipment employed by Ontario Hydro, boiler slag is not produced, but fly ash and bottom ash are.

Fly ash is the fine particulate matter precipitated from the stacks of coal-fired boilers. Due to the many variables present in its origin, production and collection, it can exhibit a wide range of physical and chemical properties, even from the same plant. The particle size and shape, the density, chemical properties and colour often vary considerably, and thus attempts to utilize fly ash as a raw material have encountered considerable difficulty. The annual production from the three Ontario Hydro plants is as follows:

Lakeview	—	300,000 tonnes
Nanticoke	—	600,000 tonnes
Sarnia	—	250,000 tonnes
Total	—	1,150,000 tonnes

Strenuous efforts have been made by Ontario Hydro and others to find a useful outlet for this material, but to date only about 25,000 tonnes per year are used, the balance being dumped in various disposal areas. In the U.S., the utilization was about 11% of the production in 1972 — as fill material, as partial replacement for cement in concrete, and in the production of sintered light-weight aggregate. The use of fly ash in Canada could increase to higher levels in the future.

Bottom ash is produced at the Ontario Hydro plants at about 10% of the rate of fly ash — in other words, there would be about 110,000 tonnes per year from the three plants. It is now all wasted. In the U.S., about 24% of the production was utilized in 1972, principally as construction fill.

The list of Class I materials should also have included *nickel slag* had this material been available in the areas considered in the TRB study. In Ontario several million tonnes of this material are produced annually, and considerable use is made of it locally in road base, construction fills, etc. It is carried over substantial distances from Sudbury for use as railway ballast. However, it is significantly heavier than most natural aggregates and it has certain chemical problems which limit its use in concrete and asphalt.

The TRB report lists 11 materials in Class II: ". . .those materials that deserve consideration for further development as aggregates which do not at this time appear to have as high a potential as Class I materials. . .do not always possess so many favourable properties, and generally require a greater amount of processing to be rendered suitable for use as aggregate." Several of these materials are not available in Ontario—such as bituminous coal refuse and slate mining waste—but incinerator residue, waste glass, and building rubble appear to merit comment.

The trend to dealing with municipal waste by incineration rather than by land fill makes disposal of the

residual ash a continuing problem. A U.S. Bureau of Mines analysis of *incinerator residues* from many different sources shows that the typical material is composed of:

30.5%	ferrous material
2.8%	non-ferrous metal
49.6%	glass
17.1%	ash, including small quantities of organic material
100.0%	

This product, with a volume equalling about 10% of the total refuse, is generally disposed of in land fill sites. Yet the danger from leachate entering groundwater is not eliminated, as heavy-metal hazards exist. This danger limits the indiscriminate use of the material into a clinker, and crushing and screening the product to produce sized aggregate, but it is an energy consumptive process and the economies do not appear attractive. The process is dependent on the high glass content of the residue. If the glass were removed from the refuse and utilized as an aggregate itself, as often proposed, the utilization of the incinerator residue would obviously be considerably affected. The waste glass can be separated and used as aggregate after crushing and sizing, as demonstrated successfully in various applications. However, the glass is worth 10 or 20 times as much to a glass producer as it is to an aggregate processor, so its best employment is obviously not as a construction material.

Large quantities of *building rubble* are produced in metropolitan centres, and are generally disposed as fill. The mixed nature of the material—concrete, bricks, mud, wood, steel, etc.—makes its employment for other purposes difficult.

However, planned utilization in the Toronto area has produced such interesting results as the Leslie Street Spit and Bluffers Park, and it would seem that such uses could continue to be found to the further advantage of most communities.

Materials assigned to Classes III and IV are not practical candidates as substitute materials for aggregates.

While useful employment for all presently wasted materials should be sought, a realistic expectation should be maintained of the part they could play in supplementing Ontario's needs for mineral aggregates. J.J. Emery of the Department of Civil Engineering of McMaster University made the statement in 1979:" . . . it is clear that they can only make a small contribution to construction needs, perhaps 5 to 10% of bulk materials. . .".

CHAPTER 6
Description of Transportation Systems

6.1 GENERAL DESCRIPTION OF TRANSPORTATION SYSTEMS

One of the prime objectives of this study was to evaluate feasible systems of transportation between the two new supply areas selected for the study and the four selected demand areas.

The transportation routes and methods that were tested are described below and shown in schematic form in Exhibits 6-1 and 6-2.

From the *Saugeen area* the following methods of line haul transportation were identified as possibly feasible:

To Toronto:	To London:	To Windsor:	To Sarnia:
—by truck	—by truck	—by rail	—by truck
—by rail	—by rail		—by rail
—by pipeline			

For Windsor, trucking was eliminated due to the long distance involved. Pipeline was only examined for transportation to the Toronto area because of the economy of scale required to make this method of transportation feasible.

Each transportation method focused on a *basic system*. In addition to the basic systems several *options* were considered that deviated from the basic system in a particular detail. The purpose of this was to determine the limits within which the selected basic system was optimal and to show when a sub-option might be more advantageous.

The basic system for *trucking* would be a direct haul from a production plant in the Saugeen supply area to the final point of use in one of the demand areas.

The basic *rail system* would be a unit-train service between major loading terminals in the Saugeen area and major receiving terminals in the demand areas. Aggregates would be trucked over short distances from excavations to large processing plants combined with loading terminals. At the receiving terminals the aggregates would be transferred to trucks and transported to the final points of use. The relative merits of by-passing either of the two major terminals, or both, were examined as options and compared with the basic system. In one case the major processing plant would be by-passed and trains would be loaded directly at a small plant near a pit. In the other case the large receiving terminal would be by-passed and direct delivery would be made by rail to a customer.

The *pipeline* would provide transportation between major loading terminals and receiving terminals. Processing, other than primary crushing, would be at the receiving end. Transportation to the loading terminals and from the receiving terminals would be provided by truck.

From *Manitoulin Island* the following methods of line haul transportation were evaluated:

To Toronto:	To Windsor:	To Sarnia:
—by rail	—by ship	—by ship
—by ship		
—by ship and rail		
—by ship and truck		

In each of these, aggregates would be quarried and processed at a marine or rail terminal on Manitoulin Island.

When line-haul was entirely by ship or entirely by rail, aggregates would be distributed from the receiving terminals to the final destination by truck.

In the combination ship/rail system the ships would carry aggregates over the first part of the route and unit trains over the second part, through a transfer terminal. Final distribution would be by truck.

In the ship/truck system, the rail component would be replaced by trucks carrying aggregates directly from the intermediate transfer terminal to the final points of delivery.

The description of each route and basic transportation alternative follows.

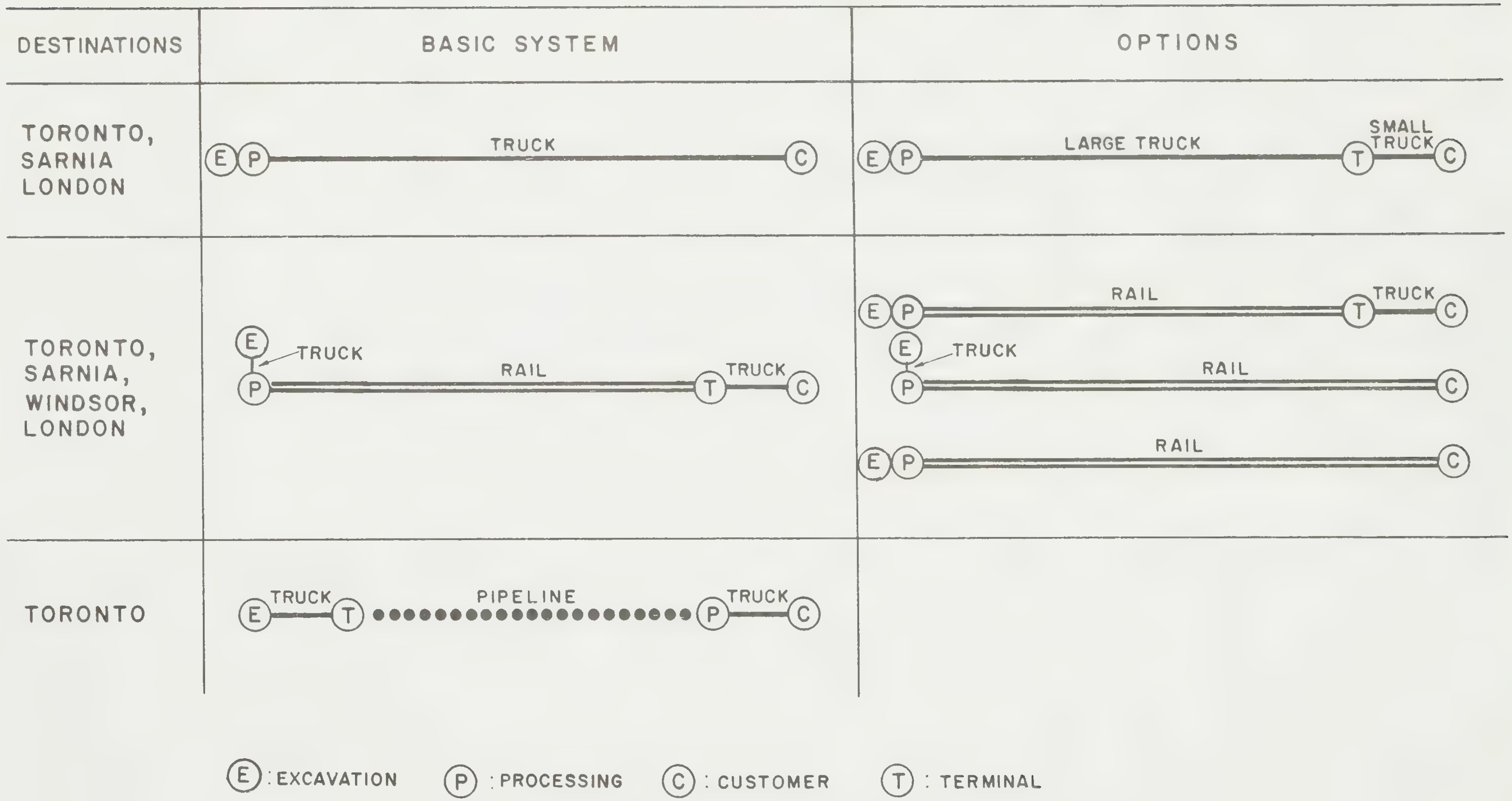
6.2 TRANSPORTATION TO THE TORONTO AREA

In order to compare the transportation alternatives on an equitable basis, a common "base" volume of aggregates had to be selected.

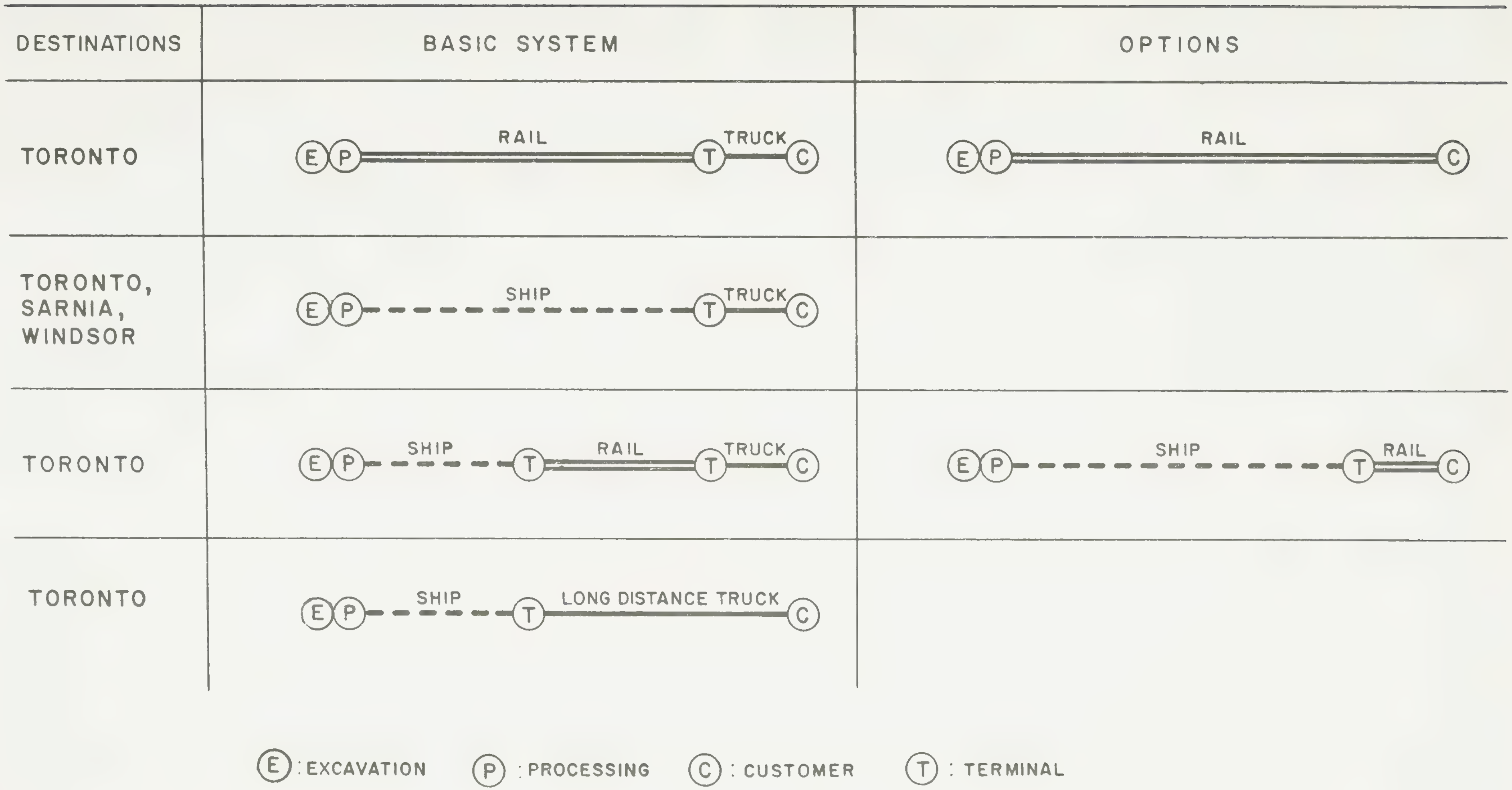
The annual volume selected as the "base" volume that would be supplied from remote sources to the Toronto area was 40 million metric tonnes. This is the approximate volume that would have to be transported to the Toronto area in the 1990's when the reserves at the existing production sites would approach depletion if no new resources were licensed. This would be the amount of sand and gravel supplied from the Saugeen area if it were the only remote source in the 1990's.

The maximum amount of stone that could be transported from Manitoulin Island to the Toronto area as part of the 40 million tonne demand would be 9 million tonnes. Since stone contains only 25% fine material, it has to be mixed with sand and gravel to satisfy the necessary mix of coarse and fine aggregates in the Toronto area; this limits the quantity of stone that can be used.

The ratio of coarse/fine aggregate demand in the Toronto area was shown to be approximately 45/55



TRANSPORTATION ALTERNATIVES FROM SAUGEEN AREA 6-1



TRANSPORTATION ALTERNATIVES FROM MANITOULIN ISLAND 6-2

percent. This mix of materials is consistent with the range available in the Saugeen area.

Considering the stone/sand ratio of materials in the Saugeen area, it would probably be difficult to achieve an average ratio of fine aggregate in excess of 62 percent. This would limit the volume of *stone* that could be transported from Manitoulin Island, as a supplement to Saugeen sand and gravel, to 9 million tonnes. Larger volumes would provide too much coarse material in relation to the requirements of the Toronto area. The same limitation applies to stone produced from underground mining.

The following quantities of mineral aggregates were thus assumed to move to the Toronto area:

Alternative	From the Saugeen Area (million tonnes)	From Manitoulin Island (million tonnes)	From Local Underground Mining (million tonnes)
A	40.0	—	—
B	31.0	9.0	—
C	31.0	—	—

6.2.1 The Present Transportation System

As described in Chapter 4 the consumption of mineral aggregates in the Toronto area was approximately 33 million tonnes in 1977. Practically all of this volume was transported to the ultimate customer by truck. Truck loads vary from 18 tonnes to 42 tonnes.

More than one half of the volume is extracted in three general locations in the Toronto area:

- Halton Hills (Halton), Milton (Halton) — approx. 7.0 million tonnes
- Caledon (Peel), Brampton (Peel) — approx. 6.5 million tonnes
- Whitchurch-Stoufville (York), Uxbridge (Durham) — approx. 6.0 million tonnes

Each of these volumes can be assumed to increase over 7 million tonnes by the mid-1980's.

Assuming mostly 35-tonne trucks by the mid-1980's the number of trucks generated by each of the three supply areas above could be 1260 loaded trucks per day on peak days (Fridays in the third quarter of the year). The average length of haul was estimated to be 35 kilometres from the source to the customers, taking about 45 minutes.

Of the 33 million tonnes approximately 2.3 million tonnes were shipped by rail into Metropolitan Toronto; however, almost all of this volume was delivered ultimately by truck.

The volume of rail transportation has shown a generally declining trend for many years.

6.2.2 Transportation by Truck from the Saugeen Area

The "basic" option for evaluating the transportation of mineral aggregates by truck from sources in the Saugeen area to customers in the Toronto area was based on 6-axle tractor-trailer units. Such units hold 35 metric tonnes of aggregate. The tractor is a three-axle unit hauling a trailer with two axles in the rear and a retractable third axle in the middle. The latter is lifted when the truck is travelling empty. This truck configuration is flexible enough to be available to deliver aggregates and unload them at most destination sites.

Other options include:

- single-unit three-axle tandem trucks carrying 18 tonnes
- three-unit eight-axle trucks carrying 45 tonnes
- line haul with the eight-axle trucks and transfer at truck-to-truck terminals to the smaller three-axle units at several locations within the Toronto area.

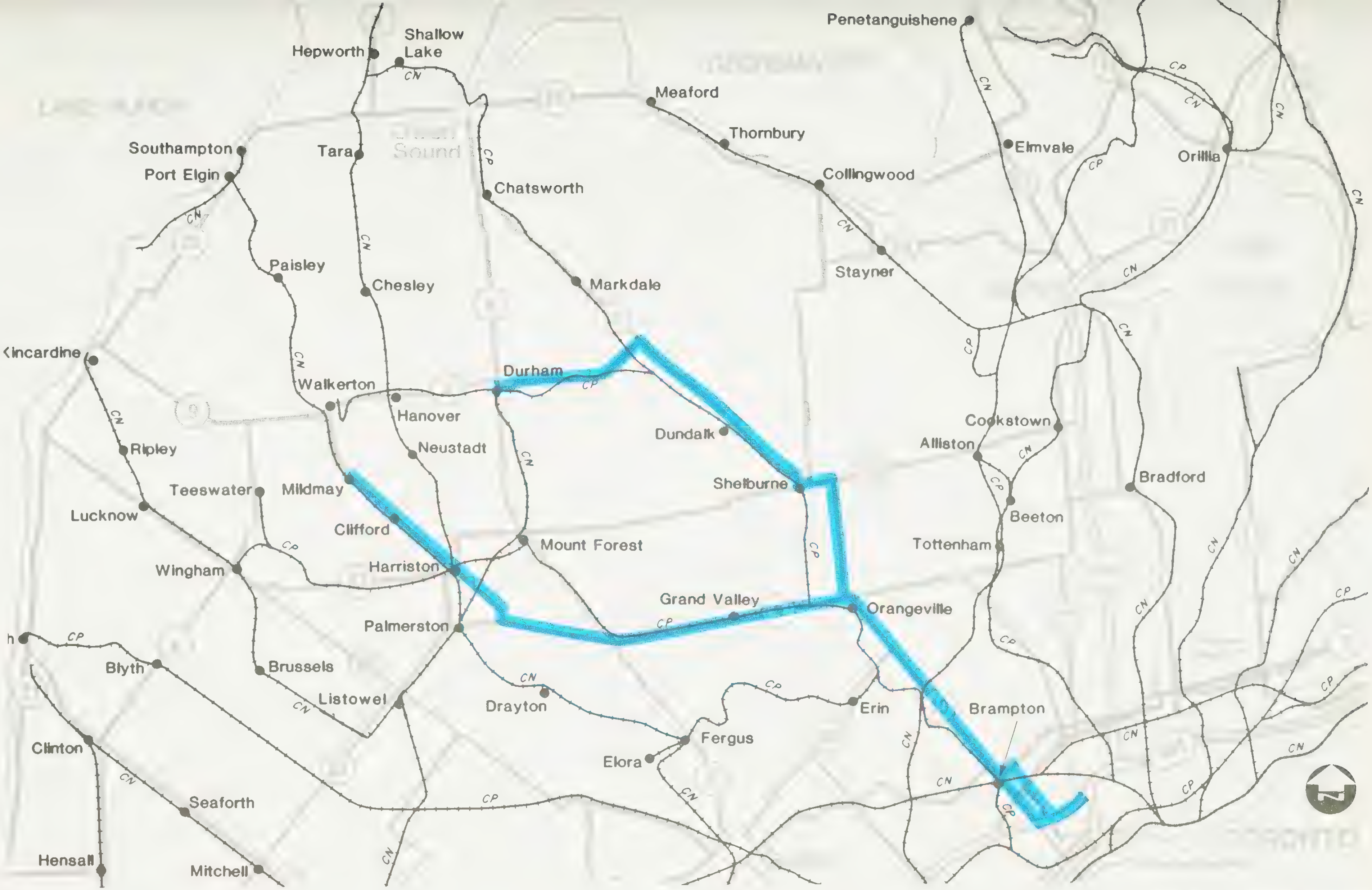
The costing of truck operations was based on seasonal patterns of aggregate demand which peaks in the summer at a monthly rate that is 12% of the annual volume.

In accordance with this pattern the truck fleet must be based on a monthly volume of 4.8 million tonnes for the supply of 40 million tonnes per year. Assuming truck loads of 35 tonnes and 21 working days per month this translates into an average of 6530 truckloads per day. The 21-day assumption is based on a 5-day per week operation and allows for statutory holidays. The peak day of the week is Friday when volumes were reported to be approximately 10 percent above those of the average day (Proctor and Redfern). Thus, facilities must be provided for 7200 truck loads per day.

The 7200 daily truck trips would originate at several pits in the Saugeen area. It is not the intention of this study to specify the exact sites of these pits. For the purpose of analysis it was assumed that the trucks would follow two different routes to the Toronto area as shown in Exhibit 6-3. The trucks would converge, however, on new Highway 410 and be dispersed by the existing and planned Toronto freeway system of Highways 400, 401, 404, 407, 410 and the East Metro Freeway.

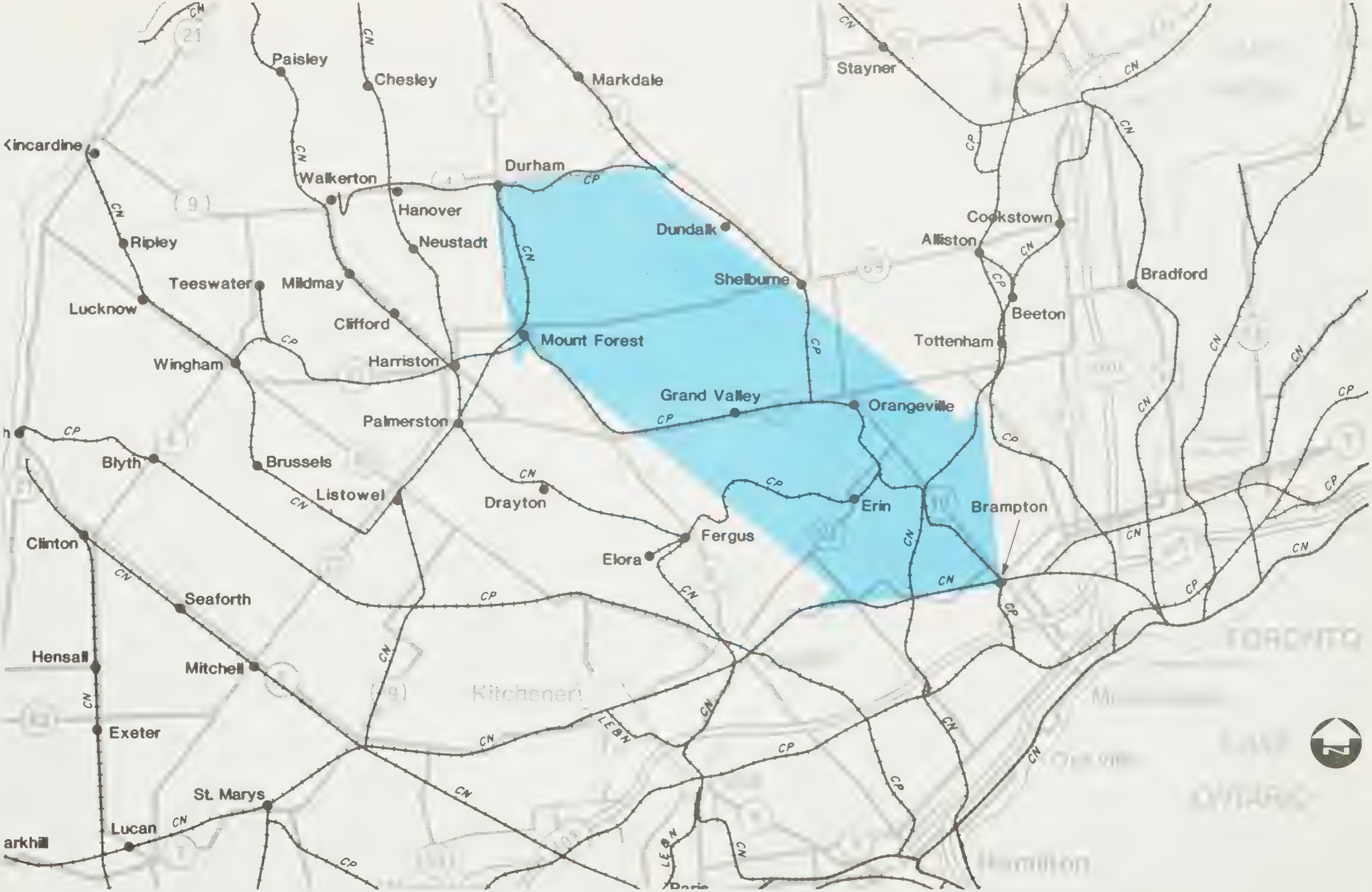
An alternative to the truck routes shown in Exhibit 6-3 is a *new highway designated entirely to aggregate traffic.* This is indicated in Exhibit 6-4. The highway would be a three-lane facility from a point near the Town of Durham to a point near Brampton where the dedicated highway would join the Toronto area freeway system. There would be no public access to this highway throughout its length except at its two ends and only mineral aggregate traffic would be allowed to use it. There would be turn-offs from the highway for deliveries en route and frequent grade separations would ensure uninterrupted crossing traffic.

The average distance from the Saugeen sites to Brampton would be 130 km. The average distribution distance from Brampton to a large number of customer locations in the Toronto area was found to be 30 kilometres (from the producer survey carried out in this study). With an average driving speed of 65 kilometres per hour (allowing for occasional stops) the average



TRUCK ROUTES - SAUGEEN TO TORONTO

6-3



NEW TRUCK ROUTE - SAUGEEN TO TORONTO

6-4

driving time would be approximately 2.45 hours from the pits to the final destinations.

Thirty minutes on average could be allowed in total for loading and unloading. Thus a total round trip, consisting of twice the one-way driving time plus the loading/unloading time would be about 5.4 hours on average. This would allow two truck trips per day during daylight hours in the main delivery season. Individual trips may, of course, be of different durations depending on the location of the customer in the Toronto area. Due to distance and street congestion the range of individual actual round trips may be between 4.5 and 6.0 hours.

Since the 7200 daily truck trips would be spread almost evenly over 12 hours, the average hourly volume would be approximately 600 trucks or 10 trucks per minute in each direction. These are *average* truck densities; it can be assumed that the *peak* density over short periods of time may be about 20 percent higher than the average. The estimated numbers of trucks are summarized in Exhibit 6-5: a peak hourly volume of 720 trucks is shown for each direction.

To appreciate this volume, a person wanting to cross a highway at such peak traffic levels would encounter a gravel truck in one or the other direction approximately every 2.5 seconds.

It is interesting to compare this volume with the *present volume*. Since there are already major aggregate sources along Highway 10 the peak traffic of aggregate trucks is already considered by many to be very high. A Proctor and Redfern survey showed average hourly traffic volumes of 60 aggregate trucks per hour in each direction. The projected future peak traffic would thus be ten times heavier.

6.2.3 Transportation by Rail from the Saugeen Area

The basic system considered in the study would consist of large rail loading terminals in the Saugeen area and of large distribution yards in the Toronto area.

The number and size would be dictated by the economics of terminal operation on the one hand and by rail economics on the other. To ensure economical railway operations, only unit trains consisting of blocks of dedicated aggregate cars were considered; such trains are not switched and carry a single load of mineral aggregates from one origin to one destination. However, the operation of the trains is not limited to the *same* origin or *same* destination on all of their trips. The essential feature of the operation is to avoid breaking up the block of railway cars at any time.

For the purpose of evaluation, trains consisting of 80 bulk rail cars were assumed, each car carrying 90.5 tonnes of aggregate, for a total trainload of 7,240 tonnes. 80 cars were chosen in a conservative way to preserve flexibility with respect to the lengths of existing passing trucks and allow for the occasional addition of cars up to 100 at times when the traffic volume may be exceptionally high. The most practical type of cars would be rotary-coupling gondola cars, suitable for trains unloaded at large bulk terminals. These cars are unloaded by rotating them along a longitudinal axis by approximately 160 degrees in each direction and dumping their contents through their tops. Since the longitudinal axis is drawn through their couplings the cars do not have to be uncoupled while being rotated, and an 80-car train can be unloaded in less than two hours, at a rate of less than three minutes for a pair of cars (unloaded simultaneously).

For trains unloaded at smaller unloading points on customers' premises bottom dump hopper cars would be more appropriate since they require less costly unloading systems. However, hopper cars have to be subjected to severe shaking for unloading their contents, resulting in much higher maintenance costs. These have to be traded off against the higher costs of the rotary dumping system required for the top-dump gondola cars. Furthermore, because they are less subject to problems caused by freezing, the transportation season for top-dump gondola cars is somewhat longer than for hopper cars. (To be on the conservative side this extra feature has not been taken into consideration in the costing of train operations in this study). Finally, the capital cost of a top-dump gondola car is significantly lower than that of the bottom-dump hopper car.

The choice of terminal equipment and the appropriate size of terminals was determined by examining the tradeoff between the turnaround times of the trains and the costs of terminal operations. In the case of large plants and common-use bulk terminals *aggregates have to be transported to the processing plants*

EXHIBIT 6–5
TRUCK TRANSPORTATION VOLUMES, SAUGEEN TO TORONTO AREA

TOTAL ANNUAL TONNAGE (million tonnes)	NUMBER OF TRUCKS					
	EACH DIRECTION			TOTAL		
	Daily	Hourly	Peak Hour	Daily	Hourly	Peak Hour
40	7200	600	720	14400	1200	1440
31	5580	465	558	11160	930	1116

over some distance by truck and, again, *distributed from the receiving terminals by truck.* The costs and other consequences of the trucking operations can be avoided by loading trains directly at the production site and/or unloading them at customers' premises. In such cases, however, the scales of operation are smaller and, therefore, less sophisticated and slower equipment is used than in a large terminal. Thus, the turnaround times of the trains becomes significantly greater, resulting in higher railway costs which have to be balanced against the lower terminal costs.

In the basic system, large scale common use terminals were assumed at both ends of the rail operation. Options to by-pass one or both of these terminals were examined subsequently.

For the *rail loading terminal* five sizes were designed and costed: for nominal annual throughputs of 1.6 million, 3.2 million, 5 million, 10 million and 20 million tonnes. Beyond 20 million tonnes there are no further economies of scale and, therefore, it is better to build separate terminals at different locations. The terminal area required for an ultimate throughput capacity of 20 million tonnes/year is in the order of 90 hectares (220 acres). The processing plants would be integrated with the transportation terminals. Only broad cost estimates were made for the processing plants but the transportation terminals were costed in greater detail.

Rail loading terminals in the Saugeen area may be located at several possible locations as shown in Exhibit 6-6. The Town of Durham is served both by C.P. Rail and C.N. Rail. On the C.P. line a bulk terminal may be located either east or west of Durham. On the C.N. system a terminal may be located south of Durham or, alternately on one of two other C.N. lines serving the area. Possible alternate terminal locations are north or south of Hanover or south of Mildmay, depending on the location of the production sites which cannot be exactly identified at this time.

For rail receiving terminals, i.e., *distribution yards*, four different sizes were designed and costed: for a nominal annual throughput capacity of 800,000 tonnes, 1.6 million tonnes, 5 million tonnes and 10 million tonnes. It was assumed that terminals handling more than 10 million tonnes would be difficult to locate in urbanized areas.

In the basic system for the Toronto area four receiving terminals (distribution yards) were considered: two near Brampton, one north of Metro Toronto and one in the Pickering/East Scarborough area. These were identified as locations where land suitable for aggregate terminals is still available and which are very well served by highways as well as high-capacity rail lines. The area required for a distribution yard of 10 million tonnes/year ultimate capacity is in the order of 70 hectares (170 acres). Exhibit 6-7 shows a sketch of the planned Toronto area freeway system: the receiving terminals would be located in a manner to provide direct access to this system without significant interferences with other regional traffic.

The railway traffic on existing routes would have a severe impact on several communities that presently experience only small volumes of traffic. An alternative is therefore to relocate substantial parts of one rail line and assign all rail traffic to that line. This would require double tracking of the line all the way.

The double-trackline would be used by both railways and would follow the C.P. route to Brampton and the C.N. route to Pickering shown in Exhibit 6-6. It would be able to carry the entire aggregate traffic between Saugeen and Toronto and thus eliminate the need for upgrading the C.N. line between Saugeen and Brampton and the considerable cost of grade separations on that line.

For evaluation and costing purposes Durham was chosen as the originating point for Toronto. The impacts of choosing other locations on costs and other characteristics is small. The capacity of all the routes shown in Exhibit 5-5 was found adequate to handle the specified volumes, provided that the physical plant was improved to a significant extent. The necessary improvements were identified and costed.

Trains would operate 7 days a week, 24 hours a day. Thus, the terminals would also operate around the clock. It was assumed in the study that the number of operational days in a year would be 230. This is approximately equivalent to eight months, allowing for a contingency of 14 days when operations may be stopped due to line repairs, derailments, labour disputes or simply lack of volume. It should be noted that in many years the actual operating season could be longer than 8 months, particularly in view of the rotary-dump unloading method which is less sensitive to freezing conditions.

Under the circumstances described, an annual volume of 20 million tonnes of aggregate could be transported from a terminal in the Saugeen area to two terminals in the Toronto area with a daily frequency of 12 trains. A summary of the transportation volumes is provided in Exhibit 6-8.

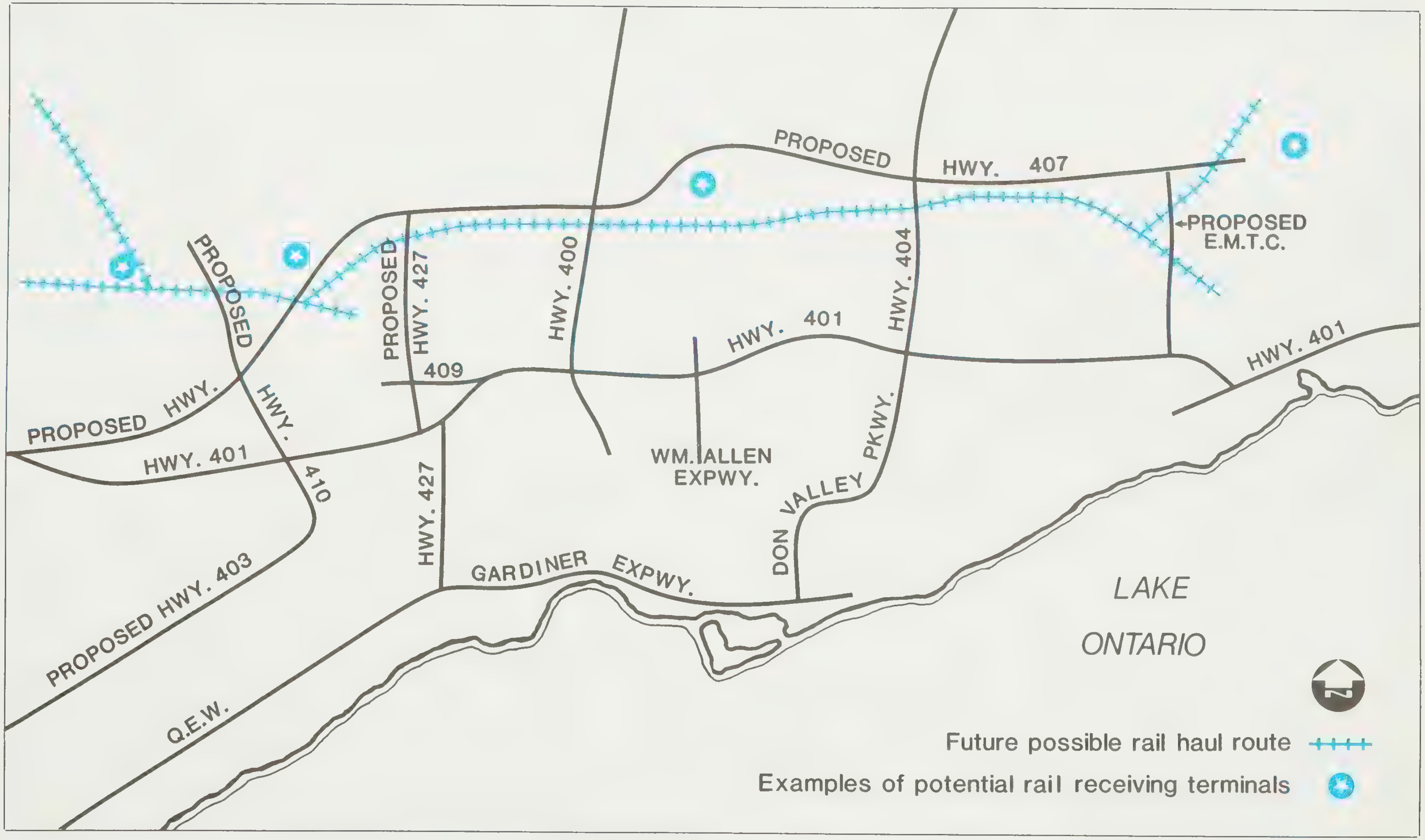
As shown in Exhibit 6-9, the average round trip time of a train between the Saugeen area and Brampton would be 13.5 hours for C.P. and 15.2 hours for C.N. The round trip time between the Saugeen area and Pickering would be 16.6 hours. The times include a total of eight hours for loading and unloading and a contingency allowance. For reasons of scheduling, additional slack time is available in a full weekly schedule for a particular train set: this amounts to approximately 3 to 4 hours per round trip if averaged over several days. This allows sufficient additional contingency time for unforeseen events and for delays due to traffic interference, mechanical faults and other reasons.

The distances involved are:

	C.P. (km)	C.N. (km)
Saugeen-Brampton:	125	170
Saugeen-N.Toronto:		185
Saugeen-Pickering:	205	

RAIL ROUTES - SAUGEEN TO TORONTO

6-6



TORONTO AREA FREEWAY SYSTEM **6-7**

EXHIBIT 6–8
RAIL TRANSPORTATION VOLUMES, SAUGEEN TO TORONTO AREA

(million tonnes)

TOTAL ANNUAL TONNAGE	FROM SAUGEEN AREA		TO TORONTO AREA			
	Terminal A	Terminal B	Brampton Terminals		Pickering Terminal	North Toronto Terminal
	CP	CN	CP	CN	CP	CN
40	20	20	10	10	10	10
31	20	11	11.5		8.5	11

EXHIBIT 6–9
RAIL DISTANCES AND ROUND TRIP TIMES, MANITOULIN ISLAND AND SAUGEEN TO TORONTO

		Distance (km)	ROUND TRIP TIMES (hours)	
			Basic Time	Additional Slack Time
Saugeen–Brampton	(CN)	170	15.2	2.3
	(CP)	125	13.5	2.7
	(DT)*	125	13.5	2.3
Saugeen–North Toronto	(CN)	185	16.2	2.4
	(DT)*	150	14.8	2.5
Saugeen–Pickering	(CP)	205	16.6	3.2
	(DT)*	187	16.1	2.7
Little Current–North Toronto	(CP)	490	28.4	3.0

*DT: Common Double Track

Both the loading and the receiving terminals would have a storage capability of approximately 10% of the annual throughput. The storage would consist of approximately 12 different products, six or seven of which make up most of the total volume, with the other five or six representing smaller quantities. The storage represents three to four weeks' demand during the non-winter season.

In the "basic system" it was assumed that 8-axle trucks with a carrying capacity of 42 tonnes would shuttle between individual excavations and the processing plant (loading terminal). They would operate 20 hours a day, 5 days a week over a period of 8 months. The frequency of trucks for an annual throughput of 20 million tonnes per plant would be about 280 deliveries per hour to each of the two plants. The average haul distance would be 10 km.

In the "basic system", distribution from the receiving terminals would be by truck, similar to the all-truck alternative discussed earlier. The average truck size assumed in the basic system was a 6-axle truck, described in the previous Section. Larger and smaller trucks would also be delivering products: for the purpose of evaluation, an average truck-load of 35 tonnes was used.

With a throughput of approximately 10 million tonnes per terminal the corresponding truck frequencies would be 1800 trucks per peak day from each of the four terminals. Trucks would operate approximtely 10 hours per day (with late afternoon pickups delivered to the customers in the morning). The peak hour volume would be 225 trucks leaving each terminal. This compares with an estimated present frequency of 60 trucks per hour observed in each direction on Highway 10.

The average distribution distance from the terminals would be approximately 15 kilometres. This corresponds to a delivery time of 25 minutes.

6.2.4 Transportation by Pipeline

Transportation of sand and gravel from the Saugeen to the Toronto area by a slurry pipeline was also evacuated. From a systems point of view the case is somewhat similar to the rail alternative with large terminals at Saugeen and Brampton. The basic difference is the line haul: instead of unit trains a slurry pipeline would be constructed.

The route of this pipeline would be similar to the route of the dedicated highway indicated in Exhibit 6-4. However, in the case of a pipeline direct routing is pos-

sible; thus, the length of a Saugeen-Brampton pipeline would only be 105 km.

A slurry preparation plant would be built in the Saugeen area which would pre-crush the pit run to a maximum size of 50 mm. The aggregate would then be transported in slurry form to a terminal in the Toronto area. The dewatering plant at the receiving end would supply the dewatered aggregates to a processing plant. The distribution yard attached to the plant would be similar to the rail distribution yards discussed earlier.

The provision and disposal of water is one of the major issues related to pipeline transportation.

To evaluate the feasibility of this alternative an annual volume of 9 million tonnes was assumed. Further evaluations were deferred pending the results of a preliminary assessment.

6.2.5 Transportation by Rail from Manitoulin Island

Manitoulin Island is served by C.P. Rail. The rail line terminates at Little Current at the northeastern tip of the Island and does not penetrate inland.

Suitable stone quarries would be a few kilometres from Little Current and the rail line may have to be extended to that area.

The transportation route is shown in Exhibit 6-10. It was assumed that the line haul would terminate at a terminal near Woodbridge since the connection between the C.P. rail line from Little Current to Brampton or Pickering represents a detour and Woodbridge is at a favourable location for distribution in the Toronto area. The annual volume assumed in the evaluation was 9 million metric tonnes of crushed stone.

The length of the rail haul from Little Current to Woodbridge is 490 kilometres. The round trip of a train would be 28.4 hours; a slack time of 3 hours per round trip was added for scheduling reasons. The capacity of the line would be adequate with some improvements; they were identified and costed in the study.

The stone would be distributed from the Woodbridge distribution yard by trucks in a manner similar to the distribution from the yards described earlier. Since the stone supplied from Manitoulin Island would supplement the aggregates received from the Saugeen area, it was assumed that the Woodbridge terminal would supply only the central parts of the Toronto area at an average distribution distance of 15 kilometres.

The delivery of 9 million tonnes per year would require approximately 1620 truckloads per day which means that approximately 200 trucks would leave the distribution yard in the peak hour.

6.2.6 Transportation by Ship from Manitoulin Island

The transportation of crushed stone by ship all the way to Toronto would be an alternative that would compete with the all-rail haul.

The ships considered for this haul in the basic system were "Seaway size" self-unloading vessels which are presently being built in Canada to specifications that are reasonably uniform. The length of such a ship is 222 metres (730 feet). Its typical carrying capacity at Seaway draft (7.92 metres or 26 feet) is 26,700 metric tonnes of stone. This is the maximum load the ship can carry through the Welland Canal. If the ship does not have to enter the Seaway it can be loaded to a draft of 9.2 metres or approximately 30 feet, carrying 32,500 metric tonnes.

For the purpose of evaluation a port location in South Bay was chosen on the south shore of Manitoulin Island. There are other potential port sites elsewhere on the Island.

The round trip time of a ship from South Bay to Toronto would be 6 days, including 2 passages through the Welland Canal and sailing the total one-way distance of 884 kilometres in each direction. Note that because of the circuitous water route this distance is almost twice as long as the rail distance.

The round trip time also includes loading and unloading times: these were assumed to total 24 hours, approximately 13 hours for loading and 11 hours for unloading. Ships would be loaded with shore-based equipment at the South Bay terminal; unloading would be done by the ship itself through its own self-unloading gear. This gear unloads the aggregates into stockpiles on shore at the receiving terminal.

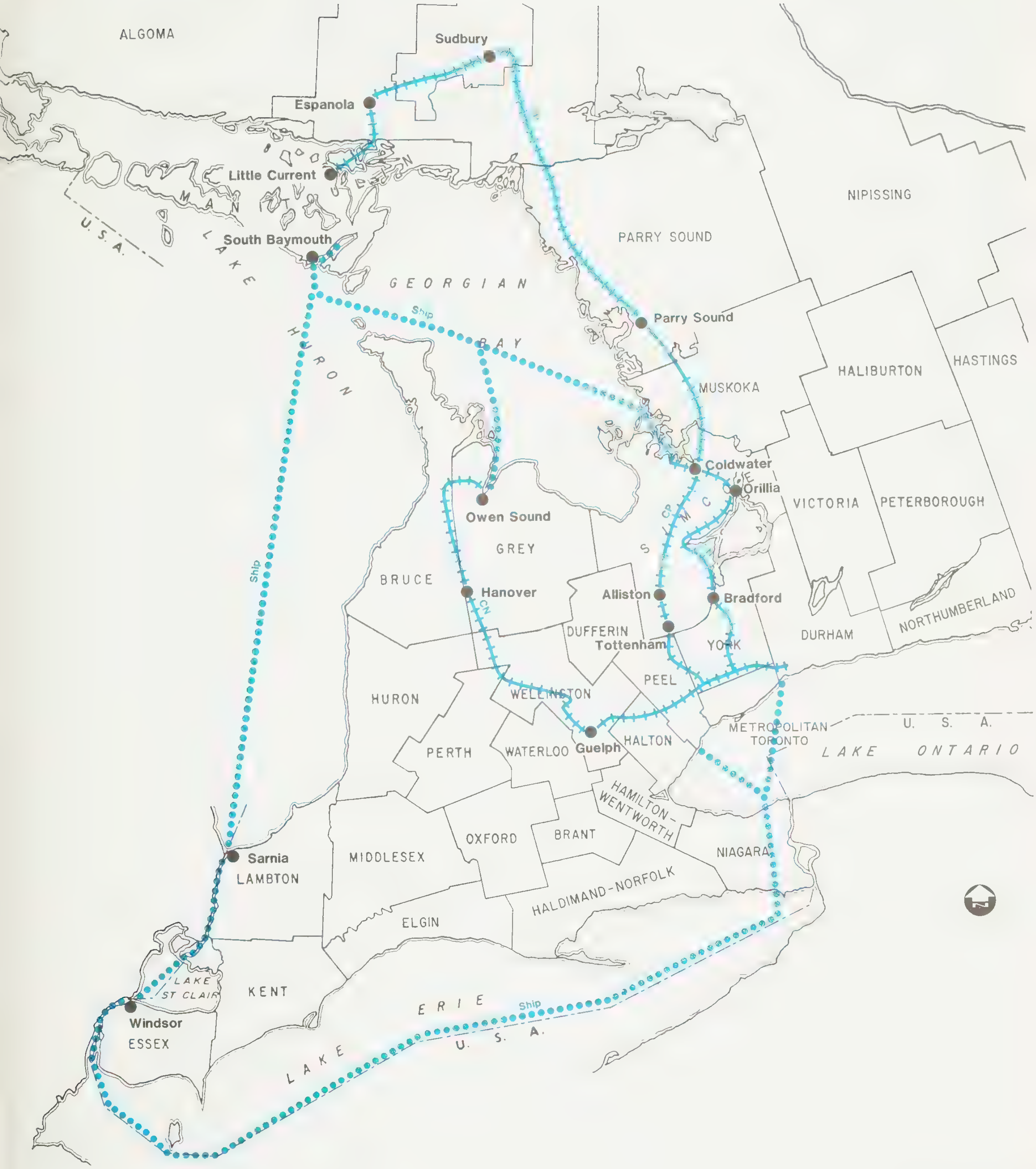
The shipping season is approximately 245 days: ships would operate 7 days a week, 24 hours a day. To deliver 9 million tonnes 337 shiploads would be required in a year. This is equivalent, on average, to 1.37 shiploads per day or 11 shiploads every eight days. With proper scheduling a single dock could handle this traffic.

It may be found quite difficult, however, to locate such a dock in the Toronto area because of the lack of suitable waterfront land and the heavy truck traffic that would be generated by a terminal. It is likely that no suitable site could be found in the central part of the area: for that reason probably two terminals would have to be built, one west of Metro Toronto and one east. Two receiving terminals would generate a distribution traffic of approximately 810 trucks per day at each terminal or 100 trucks in the peak hour. The average distribution distance would be 25 kilometres (40 minutes).

It is not believed that the average number of aggregate ships passing through the Welland Canal (3 ships per day in both directions combined) would create a capacity problem, even in the latter parts of the century. However, substantially larger volumes than 9 million tonnes/year would create problems.

It would be expected that the aggregate volumes would be transported by shiplines on the basis of long term contracts. Eight ships would have to be built for the purpose of this traffic.

Larger ship sizes cannot be used on this route because of the passage through the Welland Canal.



ROUTES FROM MANITOULIN ISLAND TO TORONTO 6–10

RAIL ROUTES - GEORGIAN BAY TO TORONTO 6-11

Thus, the ships described above represent the most economical options.

6.2.7 Transportation by Ship and Rail From Manitoulin Island.

Crushed stone from Manitoulin Island to Toronto could be shipped by water to a port north of Toronto and from there by rail to Toronto. A potential port location near Midland on Georgian Bay was chosen for the purpose of this study as a suitable transfer port. Owen Sound was also examined as an alternative.

Midland is served by both C.N. Rail and C.P. Rail. Both railway hauls were evaluated. It was assumed that C.N. would deliver to a terminal in the Brampton area. In the case of C.P. it was assumed that a terminal would be built near Woodbridge to receive aggregates from Manitoulin Island: the same terminal as assumed in the all-rail case. The rail lines are shown in Exhibit 6-11. Capacity on the lines would be adequate after improvements identified in the study.

It is unlikely that sufficient space could be found in the Midland area to accommodate both a C.P. and a C.N. terminal, therefore only one of the two services would be put in place.

As in the all-rail and the all-water case, the assumed annual volume of crushed stone was 9 million tonnes. All terminals, i.e., the loading terminal at South Bay on Manitoulin Island, the transfer terminal at Midland and the receiving distribution yards at Woodbridge or Brampton would have to handle this amount.

In the "basic system" the same type of ship would be used as in the all-water alternative, i.e., a 222-metre self-unloader. However, since the ship does not have to pass the Welland Canal, it can carry 32,400 metric tonnes, at a draft of 9.15 metres (30 feet). To deliver 9 million tonnes per year 278 shiploads would be required.

The length of the season would be 245 days. 278 shiploads over 245 days would result in a little more than one shipload per day.

The distance between South Bay on Manitoulin Island and Midland is 217 kilometres each way. This would mean a total round trip time of 2 days or 122 round trips during a 245-day season for each ship. Thus, a ship would carry almost exactly 4 million tonnes per year and 2 ships would be able to carry 88 percent of the traffic. A third ship would have to make a few additional trips.

On this route the option of using larger 300-metre (1000 foot) ships can also be evaluated. These ships carry approximately twice as much cargo as the ships described above. However, their costs are higher and they take longer to load and unload.

Rail distances from Midland and Owen Sound to the Toronto terminals and rail round trip times are shown in Exhibit 6-12.

Distribution truck distances for this alternative would be the same as for the alternatives described previously: 15 kilometres from the Woodbridge terminal.

The system described relates to an annual throughput of 9 million tonnes. If this volume was doubled in the more remote future, another transfer terminal would have to be built in another area of Georgian Bay, since it is unlikely that there would be room for more than one 9 million tonne terminal in the Midland area. Owen Sound is a potential other terminal location. Owen Sound is served by C.N. It is also served by C.P. but that line has very steep grades in the loaded direction which makes it unsuitable for heavy unit train service without major reconstruction.

The parameters of the ship haul to Owen Sound would not be much different from those to Midland.

6.2.8 Transportation by Ship and Truck from Manitoulin Island

A further alternative to transport crushed stone from Manitoulin Island to Toronto would be by ship and truck with a transfer terminal at Midland. This alternative would be similar to the alternative described above. However, in this case trucks would transport aggregates from the Midland marine terminal all the way to the ultimate customer.

The parameters of the ship operation would be the same as in the ship/rail alternative.

Trucking distances and round trip times would be as follows:

Average distance, Midland to Toronto: 130 kilometres
Average total round trip time: 4.2 hours

EXHIBIT 6–12
RAIL DISTANCES AND ROUND TRIP TIMES, MIDLAND OR OWEN SOUND TO TORONTO

			ROUND TRIP TIMES (hours)	
		Distance (km)	Basic Time	Additional Slack Time
Midland–North Toronto	(CP)	145	14.3	4.9
Midland–Brampton	(CN)	200	16.4	2.7
Owen Sound–Brampton	(CN)	216	17.4	4.9

The average truck volumes related to a 9 million tonne annual throughput would be 1620 trucks per day or 200 trucks per peak hour.

6.2.9 Local Underground Mining

The option of producing 9 million tonnes of stone from local underground mines in the Toronto area was evaluated as an alternative to transporting the equivalent amount of stone from Manitoulin Island.

Two underground mines could be developed with a capacity of 4.5 million tonnes each, at relatively short distances from the points of demand.

Truck volumes would be 810 trucks per day or 100 trucks in the peak hour at each mine site.

The average distribution distance would be the same as in the other alternative involving distribution terminals: about 15 kilometres.

6.3 TRANSPORTATION TO THE LONDON AREA

The 1977 demand for mineral aggregates in the London demand area was estimated to be 5.5 million metric tonnes. This demand is forecast to increase to 6 million metric tonnes by the mid-1980's.

The ratio of coarse/fine aggregate demand was estimated to be approximately 45/55 percent. This mix of materials would be consistent with the range available in the Saugeen area.

The transportation alternatives that were evaluated included:

- transportation from the Saugeen area by rail
- rail transportation and underground mining of stone in the London area to supplement the supplies from Saugeen.

6.3.1 The Present Transportation System

Most of the aggregate production sources are scattered throughout the eastern half of Middlesex County. There is a concentration of demand in London.

Transportation from the production site to the customers is by truck over an estimated average distance of 20 kilometres. This implies an average delivery time of approximately 30 minutes.

6.3.2 Transportation by Truck from the Saugeen Area

The truck routes from the Saugeen area to London are shown in Exhibit 6-13. The average distance would be 150 kilometres and the average round trip time would be 4.8 hours.

Assuming 6-axle trucks with an average payload of 35 tonnes, 6 million tonnes of aggregates per year would require a peak daily volume of 1080 trucks in each direction. Because of this volume, trucks would have to be assigned to two different routes. Thus, the daily peak volume on each route would be 540 trucks in each direction, or 54 in the peak hour.

6.3.3 Transportation by Rail from the Saugeen Area

The annual volume of 6 million tonnes of aggregates could be carried by 3.5 unit trains (3 or 4) per day, each consisting of 80 cars, each car carrying 90.5 tonnes of aggregate.

Terminals of various sizes were evaluated: one high capacity terminal was compared with several smaller terminals at both the loading and receiving ends.

The rail line between the Saugeen area and London is served by C.N. It is shown in Exhibit 6-13. Distances and round trip times are shown in Exhibit 6-14.

The high capacity loading terminal was assumed to be at some distance from the terminals supplying Toronto.

A suitable location for a high capacity receiving terminal (distribution yard) would be northeast of London before the rail line enters the city. For an annual throughput of 6 million tonnes the number of distribution trucks would be 1080 on the peak day, 108 in the peak hour in each direction. The average distribution distance would be about 15 kilometres, the delivery time 25 minutes.

6.3.4 Local Underground Mining

The amount of stone that could be produced locally through underground mining is limited by the requirement of 55 percent fine aggregates in the mix of materials. This limits the amount of stone produced locally to 2 million tonnes, leaving 4 million tonnes of sand and gravel to be supplied from the Saugeen area. Even then the latter would have to contain 70 percent fine aggregates.

If stone were produced locally from underground mining the numbers of trucks and trains carrying sand and gravel from the Saugeen area could be reduced by one third.

6.4 TRANSPORTATION TO THE WINDSOR AREA

The 1977 demand for mineral aggregates in the Windsor area was estimated to be approximately 3.0 million tonnes. This demand is expected to increase to 3.5 million tonnes by the mid-1980's.

The ratio of coarse/fine aggregate demand was estimated to be 45/55 percent. This mix of materials would be consistent with the range available in the Saugeen area.

The transportation alternatives that were evaluated included:

- Transportation of coarse aggregates by water from Manitoulin Island and of fine aggregates by truck from the United States.
- Transportation of aggregate by rail from the Saugeen area.
- Replacement of the water transportation of coarse aggregates by local underground mining.

ROUTES TO LONDON, SARNIA, WINDSOR 6–13

Transportation of fine aggregates from the Saugeen area to replace U.S. supplies has been evaluated as a contingency option, should the trucking of fine aggregates from the United States be disrupted for some reason.

Trucking of aggregates from the Saugeen area to the Windsor area was not considered a feasible alternative due to the long distance and high costs.

6.4.1 The Present Transportation System

In 1977 approximately 0.65 million tonnes of mineral aggregates were imported to the Windsor area by water from Michigan. The following quantities were unloaded at two ports:

	Crushed Stone (thousand tonnes)	Sand and Gravel (thousand tonnes)
Windsor	480	80
Kingsville (Lake Erie)	90	—

Crushed stone is produced locally in the Amherstburg area, approximately 25 kilometres from Windsor. Sand is produced in the Leamington area, approximately 50 kilometres from Windsor. Sand is also trucked to Windsor from Michigan.

Transportation from the marine terminals and from the production sites in Essex County is by truck. The average trucking distance, including the Canadian part of the transborder trucking was estimated to be 25 kilometres for the loaded haul. The corresponding delivery time is approximately 35 minutes.

6.4.2 Transportation by Ship from Manitoulin Island

The demand for aggregates in the mid-1980's is forecast to be 3.5 million tonnes of which coarse aggregates represent 1.6 million tonnes. This means that approximately 2.0 million tonnes of stone could be transported by ship and the remaining 1.5 million tonnes of fine aggregates could be trucked across the border from Michigan.

To ship 2 million tonnes of aggregates annually from Manitoulin Island, 71 shiploads would be required. The sailing distance is 402 kilometres each way and the estimated total round trip time, including loading and unloading, would be 3 days. The draft restrictions (8.23 metres) in the St. Clair River allow a maximum shipload of 28,200 tonnes. The ship route is shown in Exhibit 6-15.

During the 245 day shipping season one ship could perform 82 round trips: sufficient to handle the entire volume.

In the water transportation alternative evaluated in this study, stone would be shipped from a marine terminal on Manitoulin Island. That terminal has been described in Section 6.2.6.

Existing marine terminals at Windsor can handle 2.0 million tonnes of stone per year without difficulty. If a terminal handled 1.0 million tonnes per year, the truck concentration at the terminal would be approximately 180 trucks on a peak day or 22 trucks in the peak hour. Since there is a concentration of demand around the City of Windsor, it was estimated that in the water transportation option average trucking distances would be reduced to approximately 20 kilometres, representing a delivery time of 30 minutes.

The number of trucks crossing from the United States would be 270 on a peak day and 34 in the peak hour. This may cause some congestion at border crossings if appropriate provisions are not made to accommodate the traffic.

6.4.3 Local Underground Mining

The stone transported by ship in the previous alternative can be replaced by local production through underground mining. With regard to local transportation this alternative would be similar to the water transportation alternative except that stone would be trucked from the mines instead of the marine terminals.

6.4.4 Transportation by Rail from the Saugeen Area

If a total volume of 3.2 million tonnes of aggregate was transported by rail from the Saugeen area, two trains per day could supply the required volumes. In that case a small amount (0.3 million tonnes) of stone would still be shipped by water in order to keep rail transportation at its most efficient level. Multiples of full daily trainloads (approximately 1.6 million tonnes per year) are the most cost-effective quantities.

EXHIBIT 6–14
RAIL DISTANCES AND ROUND TRIP TIMES, SAUGEEN AREA TO SOUTHWESTERN ONTARIO

		Distance (km)	ROUND TRIP TIMES (hours) Basic Time	Additional Slack Time
Saugeen–London	(CN)			
– High Capacity Terminal:		135	13.7	2.3
– Low Capacity Terminal:		148	28.7	7.3
Saugeen–Windsor	(CN)	345	36.9	11.1
Saugeen–Sarnia	(CN)	265	33.0	15.0

These volumes do not justify large terminals. The required volumes could be supplied from one loading terminal in the Saugeen area to two receiving terminals in the Windsor area. The railway cars proposed for this traffic would be bottom-dump hopper cars which are suitable for unloading at small terminals.

The rail line from the Saugeen area to Windsor is served by C.N. and shown in Exhibit 6-13. It is common with the line to London and Sarnia between the Saugeen area and London. Rail distances and round trip times are shown in Exhibit 6-14.

A "contingency option" would be the supply of only fine aggregates from the Saugeen area to the Windsor area should the supply from the United States be disrupted for some reason. 1.6 million tonnes of fine aggregates could be supplied by one train per day from a single loading terminal in the Saugeen area to a single receiving terminal in the Windsor area. However, a market for the by-product coarse aggregate, amounting to 1.6 million tonnes per year would have to be found.

6.5 TRANSPORTATION TO THE SARNIA AREA

The 1977 demand for mineral aggregates in the Sarnia area was estimated to be approximately 2.1 million tonnes. This volume is expected to remain approximately constant until the mid-1980's.

The ratio of coarse/fine aggregate demand was estimated to be 45/55 percent. This mix of materials would be consistent with the range available in the Saugeen area.

The transportation alternatives that were considered include:

- Transportation of coarse aggregates by water from Manitoulin Island and of fine aggregates by truck from the United States.
- Transportation of aggregates by rail from the Saugeen area.
- Replacement of the water transportation of coarse aggregates by local underground mining.

Transportation of fine aggregates from the Saugeen area to replace U.S. supplies has been evaluated as a contingency option, should the trucking of fine aggregates from the United States be disrupted for some reason.

6.5.1 The Present Transportation System

In 1977 approximtely 1.05 million tonnes of mineral aggregates were imported to the Sarnia area by water from Michigan in the United States. The following quantities were unloaded at two ports:

	Crushed Stone (thousand tonnes)	Sand and Gravel (thousand tonnes)
Sarnia	730	20
Sombra (St. Clair River)	300	0

Sand is produced locally near Blackwell, approximately 5 kilometres east of Sarnia and at Reeces Corners, approximately 25 kilometres east of Sarnia. Higher quality sand is trucked to Sarnia from Michigan.

Transportation of aggregates from the marine terminals and the production sites in Lambton County is by truck. The average trucking distance, including the Canadian part of the transborder trucking was estimated to be 20 kilometres for the loaded haul. The corresponding delivery time is approximately 30 minutes.

6.5.2 Transportation by Ship from Manitoulin Island

The demand for aggregates in the mid-1980's is forecast to be 2.1 million tonnes of which coarse aggregates represent 1.0 million tonnes. This means that approximately 1.3 million tonnes of stone can be transported by ship and the remaining 0.8 million tonnes of fine aggregates could be trucked across the border from Michigan.

To ship 1.3 million tonnes of aggregates annually from Manitoulin Island, 46 shiploads would be required. The sailing distance is 303 kilometres each way and the estimated total round trip time, including loading and unloading, would be 2.5 days. The same draft restrictions (8.23 metres) apply as for Windsor resulting in a maximum shipload of 28,200 tonnes. The ship route is shown in Exhibit 6-15.

During the 245-day shipping season a ship could perform 98 round trips; thus, one ship using about one half of its available time could supply the volumes.

In the water transportation alternative evaluated in this study, stone would be shipped from a marine terminal on Manitoulin Island. That terminal has been described in Section 6.2.6.

Existing marine terminals at Sarnia can handle 1.3 million tonnes of stone per year without difficulty since they already handle similar amounts. If one terminal handled all of this volume, the truck concentration would be approximately 235 trucks on a peak day or 29 trucks in the peak hour. Since there is a concentration of demand around the City of Sarnia, it was estimated that in the water transportation option, average trucking distances would be reduced to approximately 15 kilometres, representing a delivery time of 25 minutes.

The number of trucks crossing from the United States would be about 145 on the peak day and 18 in the peak hour. This may cause some congestion at border crossings if appropriate provisions are not made to accommodate the traffic.

6.5.3 Local Underground Mining

The stone transported by ship in the previous alternative could be replaced by local production through underground mining. With regard to local transportation this alternative would be similar to the water transportation alternative except that stone would be trucked from the mines instead of the marine terminals.

SHIP ROUTE – MANITOULIN ISLAND TO SARNIA AND WINDSOR

6–15

6.5.4 Transportation by Rail from the Saugeen Area

The most efficient transportation volumes by rail are those that ensure full daily train loads. Since a train can carry approximately 1.6 million tonnes per year, one train per day could supply that volume. In that case, a relatively small amount (0.5 million tonnes) of stone would still be shipped by water.

These volumes do not justify large terminals. The required volumes could be supplied from one loading terminal in the Saugeen area to one receiving terminal in the Sarnia area. The railway cars proposed for this traffic would be bottom-dump hopper cars which are suitable for unloading at small terminals.

The rail line from the Saugeen area to Sarnia is served by C.N. and shown in Exhibit 6-13. It is common with the line to London and Windsor between the Saugeen area and London. Rail distances and round trip times are shown in Exhibit 6-14.

A "contingency option" would be the supply of only fine aggregates from the Saugeen area to the Sarnia area should the supply from the United States be disrupted for some reason. 0.8 million tonnes of fine aggregates could be supplied by one train every second day from a single loading terminal in the Saugeen area to a single receiving terminal in the Sarnia area. However, a market for the by-product coarse material, about 0.8 million tonnes per year, would have to be found.

6.5.5 Transportation by Truck from the Saugeen Area

It would be possible to transport the 0.8 million tonnes of fine aggregate identified above by truck all the way from the Saugeen area. This alternative has been evaluated for comparison with the rail alternative, although the distance (200 kilometres) appeared to be prohibitive in the first assessment. The evaluation served the purpose of showing the cost differences between rail and truck transportation over such a long distance.

Truck volumes would be quite small (145 per day, 18 per peak hour) and would probably be distributed among several routes.

CHAPTER 7
Components of the Transportation Systems

Chapter 6 described the total transportation systems and how they would operate, should long distance transportation be required to supply mineral aggregates to four demand areas. These systems included several transportation modes: – trucks, railways, ships and pipelines. The total systems also include the roads, rail lines and terminals.

This Chapter summarizes the capital and operating costs of the various components of the systems and presents more details on their characteristics.

The costs of all components in the transportation systems are then combined in Chapter 8 to provide estimates of the final price of delivered aggregates in each system.

7.1 DESCRIPTION AND COSTING OF TRUCKS

7.1.1 Truck Types

The truck types considered in the study are shown in schematic form in Exhibit 7-1, including an indication of their maximum payload.

Types A and B are so-called "trains" consisting of a tractor and two trailers. Type A is a dump truck from which the material is unloaded through the rear by lifting the front of the trailer body, using a hydraulic mechanism. Type B is a truck fitted with hoppers allowing the material to be dumped through the bottom of the trailers.

Types C and D are tractor-trailer units with single trailers. Type E is a so-called "tandem" (3-axle) truck with a fixed body. They are dump trucks which operate in a similar way as Type A.

It was assumed in the study that truck type E would not be used for long distance transportation because of high costs. This is a typical distribution truck for local use.

Average driving speeds of 65 km per hour were assumed for the trucks on public highways and 75 km per hour on a special highway dedicated to aggregate traffic. In urban areas an average speed of 35 km per hour was assumed. A total of 15 minutes was allowed for loading and unloading the trucks.

7.1.2 Costing of Truck Movements

The costing of line haul was carried out for three truck sizes:

- 8-axle trucks (Type A or B)
- 6-axle trucks (Type C)
- 5-axle trucks (Type D).

The truck costs were divided into three major groups:

- fixed costs
- variable (operating) costs
- overhead costs.

Fixed costs consist of *capital costs and licence fees* These are shown for each truck type in Table 7-1. All costs are at 1979 levels.

Fixed costs were translated into annual and daily costs by assuming that on debt (bank loans), the interest would be 12 percent and on equity the rate of return would be 18 percent of the investment. A debt/equity ratio of 70/30% was assumed for tractors, 50/50% for trailers and 60/40% for straight trucks. Inflation of 8 percent was assumed which implies that the costs and the revenues of the trucking operation would increase by that rate each year. The 18 percent rate of return would be achieved under these circumstances. If the rate of inflation were to decrease, the rate of return would be lower.

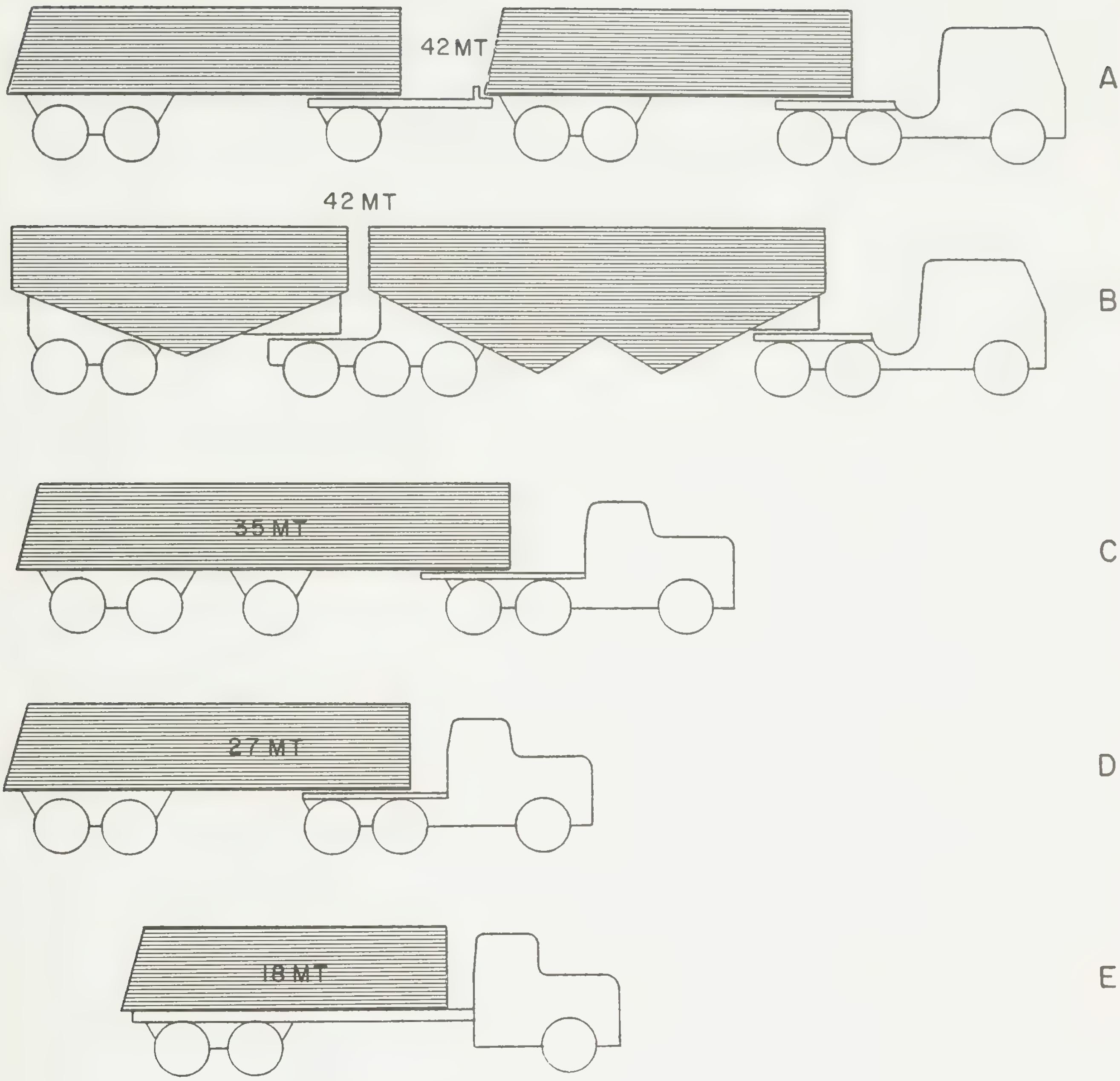
Other assumptions are indicated in Exhibit 7-2. The resale value of tractors was taken into consideration by assuming that a loan would be taken out at 12 percent interest when the new truck is purchased and repaid 6 years later, equalling its resale value at that time.

The average number of operating days in a year, considering the seasonality of aggregate traffic, was assumed to be 175 days.

The variable costs included the following elements:

- fuel
- driver wages
- repairs
- tires
- cleaning
- other costs.

Fuel costs were based on a 1979 average diesel oil cost of 19.8 cents per litre (90 cents per gallon). This was lower than the general retail cost of diesel oil in 1979 since it included discounts received by most motor carriers from oil companies for bulk purchases. These discounts are usually in the order of 10 percent of the gas pump price (which was, on average, $1.00 per gallon in 1979).



PAYLOADS IN METRIC TONNES (MT)

TRUCK TYPES 7-1

EXHIBIT 7–2
TRUCK FIXED COSTS

(1979 dollars)

TRUCK TYPE	AXLES	TONNES	CAPITAL COSTS (NEW) TRACTOR	TRAILER(s)	TOTAL	ANNUAL COSTS OF CAPITAL TRACTOR	TRAILER(s)	TOTAL	ANNUAL LICENCE FEE	TOTAL ANNUAL FIXED COSTS
A	8	42	$62,500	$46,000	$108,500	$12,466	$10,079	$22,545	$2,143	$24,688
B	8	42	62,500	46,000	108,500	12,466	10,079	22,545	2,143	24,688
C	6	35	55,000	28,500	83,500	10,970	6,244	17,214	1,727	18,941
D	5	27	52,000	20,500	72,500	10,371	4,492	14,863	1,394	16,257
E	3	18	57,000	—	57,000	10,154	—	10,154	891	11,045

NOTE: • Includes sales tax and provision for discount from list price.
• Annual costs assume 35% resale value for tractors after 6 years, 25% resale value for tandum truck (E) after 8 years.
• Depreciation over 5 years for tractors and 7 years for trailers and truck (E).

The price of diesel fuel was made up of the following components:

– Crude oil component:	8.3 cents/litre*
– Transportation of crude, refining and distribution:	4.6 cents/litre
– Federal sales tax:	1.0 cents/litre
– Provincial tax:	5.9 cents/litre
	19.8 cents/litre

Of these cost elements, the cost of crude transportation, refining and distribution are subject to general inflation. All the other elements are subject to government policies.

The fuel consumption for trucks varies significantly depending on the terrain, equipment efficiencies and driver performance. Estimates for average fuel consumptions were:

(A, B) 8-axle truck: 1.5 km per litre
(C) 6-axle truck: 1.6 km per litre
(D) 5-axle truck:1.7 km per litre
(E) 3-axle truck:1.95 km per litre.

These are averages for driving both on highways and urban areas. A typical 6-axle truck would be able to run approximately 1.7 km per litre on the highway and consume approximately 35 litres per hour in urban areas with frequent stops.

EXHIBIT 7–3
DRIVER WAGES IN ONTARIO

(1979 dollars)

	TRUCK TYPES A, B	C	D	E
Payload, tonnes	42	35	27	18
Per hour				
Basic	8.93	8.93		
Fringe Benefits	1.34	1.34		
Total	10.27	10.27		9.00*
Per kilometre				
Basic	0.1438	0.1371		—
Fringe Benefits	0.0216	0.0206		—
Total	0.1654	0.1577		—

*Mean value between industry estimates and wages shown in Transport Canada publication "Operating Costs of Trucks in Canada – 1978". Source of all other data: "Operating Costs of Trucks in Canada", inflated to 1979 wage levels.

Driver wages were defined either by the hour or by the mile, whichever produced a higher amount. The 1979 average wage levels are shown in Exhibit 7-3.

In the case of line haul the mileage rate is relevant. Loading/unloading time is paid by the hour.

The cost of *tires, repairs, cleaning and other categories* are shown in Exhibit 7-4.

Overhead costs included insurance, administrative costs and interest related to working capital and to facilities or equipment other than trucks.

As an industry average, a markup of 15 percent was applied to the total of fixed and variable costs to account for overhead costs.

The results of the cost calculations are summarized in Exhibit 7-5. Truck rates from Saugeen to Toronto, London and Sarnia were determined. The truck rates between Midland and Toronto (for the ship/truck transportation alternative) were not calculated at this stage.

Since the truck costs included returns on investment and overhead costs, it was assumed that truck *rates* would equal these costs.

Rates in cents per tonne-kilometre are shown in Exhibit 7-6.

It is obvious from the Exhibit that a 5-axle truck is uneconomical for long distances when compared to a 6-axle truck. It can also be concluded that an 8-axle truck is only marginally more economical than a 6-axle

truck; because of less flexibility and slower unloading at many locations the 8-axle truck types were therefore not used in subsequent evaluations and the economic comparisons were based on the costs of 6-axle trucks.

Rates per tonne for the distribution of aggregates by truck from production sites or from terminals to customers were calculated and expressed as the sum of a fixed part and a part that depends on distance. The following rates were developed:

	Fixed Part cents/tonne	Variable Part cents/tonne-km
18-tonne truck	75	6.0
35-tonne truck	50	4.2

7.2 ROAD COSTS AND REVENUES

7.2.1 Toronto Area

As described in Chapter 6 the transportation of 40 million tonnes of aggregates would require 7200 trucks per day or 720 trucks during the peak hour in each direction. In the two directions combined this would mean one aggregate truck every 2.5 seconds.

Such density of traffic could only be handled on a freeway. It was found, therefore, that the only feasible way in which such volume of aggregate truck traffic could be handled would be the construction of a special freeway between the Saugeen and the Toronto areas.

Since the region between Saugeen and Toronto is well served by roads, the only purpose of the new freeway would be to handle the aggregate traffic. In order to keep costs to a minimum and to minimize interference with other traffic, the best option would therefore be to build an exclusive three-lane freeway *dedicated* to aggregate trucks and closed to general traffic. The dedicated freeway would avoid built-up areas. Its length would be approximately 120 kilometres and its cost was estimated to be 130 million dollars.

Assuming a required rate of return to the Province of 12 percent, an inflation rate of 8 percent per year and an economic life of 25 years the required annual cost recovery would be 6.7 percent of the total capital expenditure in the initial year of operation (increasing by the rate of inflation every year). This would result in an annual cost recovery requirement of 8.7 million dollars to the Province of Ontario in 1979 dollars. With an annual maintenance cost of 0.5 million dollars the total annual cost of the Saugeen-Toronto dedicated road would be 9.2 million dollars at 1979 price levels.

The average fuel consumption of aggregate trucks was estimated to be 0.0375 litres/loaded tonne-kilometre (including allowance for empty return). With a Provincial fuel tax revenue of 5.9 cents/litre the Provincial revenue would thus be 0.22 cents per loaded tonne-kilometre. In the present delivery system the average fuel consumption of trucks was estimated to be 0.044 litres/loaded tonne-kilometre and the Provincial revenue 0.26 cents per loaded tonne-kilometre.

Another Provincial income is that derived through licence fees. Assuming trucks with 35 tonne payload the annual licence fee is $1,727 per truck. In today's delivery system in the Toronto area the average truck of that size can deliver approximately 35,000 tonnes per year. For the Saugeen-Toronto run the same truck would be able to deliver approximately 10,000 tonnes per year (assuming two trips per weekday and 350 trips per year). Calculations show that with an annual volume of 40 million tonnes the increase in Provincial revenues would be $15.4 million. This is significantly more than the annual cost of the road.

7.2.2 London Area

Because of significantly lower truck volumes existing highways could be used to supply aggregates to the London area from the Saugeen area. However, road improvements would be required, especially in pavements. These have been estimated to cost $31 million in 1979 terms.

Calculations of the annual costs of these improvements indicate that these costs would also be balanced by the Provincial revenues derived from the increased fuel consumption of aggregate trucks. Since the volume of aggregates needed in the London area would be 6 million tonnes, i.e., 15 percent of the volume transported to Toronto, and since the distance is similar, the incremental Provincial revenue derived from long distance aggregate transportation would be approximately $2 million. This amount would be broadly equal to the annual cost of road improvements between Saugeen and London.

EXHIBIT 7–4
TRUCK OPERATING COSTS

(1979 dollars)	TRUCK TYPES				
	A	B	C	D	E
Payload (tonnes)	42	42	35	27	18
	– costs in $/km –				
Tires	.0696	.0696	.0497	.0398	.0200
Repairs	.1696	.1696	.1366	.1366	.1056
Cleaning	.0186	.0186	.0186	.0186	.0152
Other	.0298	.0298	.0298	.0298	.0099
Total	.2876	.2876	.2347	.2248	.1507

EXHIBIT 7–5
TRUCKING RATES

($/tonne)	ONE-WAY DISTANCE km	6-AXLE 35 tonne payload	8-AXLE 42 tonne payload
Saugeen–Toronto	160	7.40	7.20
Saugeen–London	145	6.85	6.75
Saugeen–Sarnia	200	8.75	8.50

7.3 DESCRIPTION AND COSTING OF RAILWAY OPERATIONS

7.3.1 Description of Railway Operations

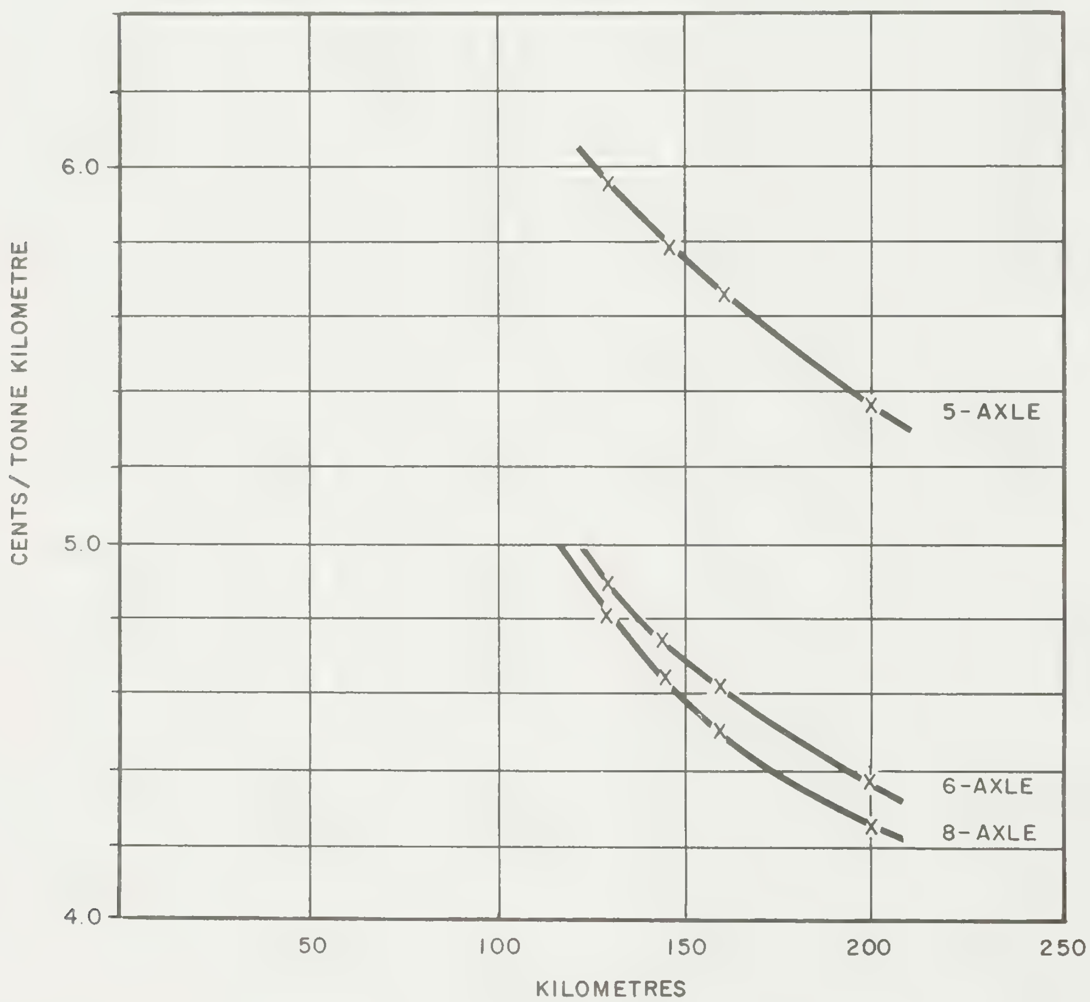
The most efficient method of rail transportation for large volumes of bulk commodities is transportation by unit train. The cars and locomotive of a unit train are completely dedicated to a particular traffic and they shuttle between their loading and unloading points according to a specified schedule.

As described in Chapter 6, the unit train for mineral aggregates would consist of 80 gondola cars equipped with rotary couplings, so that the cars would not have to be uncoupled while rotating them around a longitudinal axis during unloading.

Although unit trains consisting of 100 cars exist, designing the system for 80 cars would allow a margin between the maximum and the design capacity of the system.

Each car would carry 90.5 tonnes of material, for a total trainload of 7,240 tonnes. Four 3,000 horsepower locomotives would be assigned to the train.

It was assumed that trains would operate 230 days per year during the aggregate production season. This is somewhat less than 8 months, allowing for breaks in operation due to accidents or work stoppages. Because of the seasonal traffic it was assumed that the railway would provide the locomotives. However, the cars would be provided by the shippers and would probably be idle during the winter. In order to simplify the presentation of rates, it was assumed that the shippers would lease the cars to the railways for an



ESTIMATED TRUCK RATES 7-6

amount that would be charged back to the shippers as part of the rates.

Round trip times were based on the available power and the gradient profiles of the rail lines. The number of necessary passing tracks was determined for the single track sections of the lines to allow the passing of trains moving in opposite directions. It was found that, on average, new passing tracks would be required approximately 20 kilometres apart.

The railway lines under consideration were shown in Chapter 6.

Four hours were allowed for loading and four hours for unloading the trains. The train schedules were constructed in such a manner that arrival and departure times at the terminals were the same every day, or alternating every second day so that the railways could easily reconcile the movements of the aggregate trains with other traffic. In order to achieve this objective "slack" time had to be added to the net round trip time. The "slack" time which amounted to approximately 10 to 20 percent of the net round trip time was also needed to provide contingency time for catching up with delays.

Round trip times from the various loading points considered in the study to receiving points in the Toronto, London, Windsor and Sarnia areas and back to Saugeen are shown in Exhibit 7-7. The annual amounts of aggregates delivered by the trains and the number of required train sets are also shown.

7.3.2 Costing of Rail Movements

The costs of railway operations were estimated using a rail costing model developed independently from the railways. The model is based on published statistical information on railway expenses, for a large number of expense categories. The model allocates these expenses to various performance (output) units such as grosse tonne-kilometres, carloads, diesel unit kilometres, net tonne kilometres, train hours and kilometres, car days and kilometres.

The model allocates system-wide railway expenses, published under various account headings, to these performance units on the basis of published information from various sources. However, the exact formulae and data used by the railways for allocating their costs are not available to the public and, therefore, certain assumptions were made in the costing model to estimate the railways' methods as closely as possible. It is not claimed however, that those methods can be perfectly duplicated from published information.

The railways were asked to supply estimates of the rates that they would charge for the type of traffic under consideration. This would have served as a check against the estimates made in the study. How-

EXHIBIT 7–7
RAIL DISTANCES AND ROUND TRIP TIMES

		DISTANCE	ROUND TRIP TIMES		ANNUAL VOLUME	NUMBER OF TRAIN SETS
			Basic Time	Additional Slack Time		
		km	hours	hours	million tonnes	
Saugeen–Brampton	(CN)	170	15.2	2.3	10	4.5(2)
	(CP)	126	13.5	2.7	10	4.5(2)
	(DT)(1)	126	13.5	2.3	20	8.5(2)
Saugeen–North Toronto	(CN)	185	16.2	2.4	10	4.5(2)
	(DT)(1)	151	14.8	2.5	10	4.5(2)
Saugeen–Pickering	(CP)	204	16.6	3.2	10	4.5(2)
	(DT)(1)	187	16.1	2.7	10	4.5(2)
Little Current–North Toronto	(CP)	489	28.4	5.2	9	7
Midland–North Toronto	(CP)	145	14.3	3.7	9	4
Owen Sound–Brampton	(CN)	216	17.4	5.1	9	5
Saugeen–London	(CN)					
– High Capacity Terminal:		135	13.7	2.3	6	2.5(2)
– Low Capacity Terminal:		148	28.7	3.3	6	4
Saugeen–Windsor	(CN)	344	36.9	11.1	3.2	3
Saugeen–Sarnia	(CN)	265	33.0	15.0	1.6	2

(1) DT: Double Track, jointly used by CN and CP.
(2) Train sets alternate between routes.

ever, the railways were unable to quote rates for a "hypothetical" traffic at this time.

Railway costs were divided into three categories:

- Direct variable costs
- Indirect variable costs
- Markups.

Direct variable costs are applied independently of the railways' expenses in their total system. They include:

- fuel costs
- crew wages, including fringe benefits
- locomotive capital costs
- car capital costs

Direct costs can be estimated quite accurately since all the necessary cost elements such as the capital costs of a locomotive or a car, crew wage rates and the consumption and costs of diesel fuel are known with reasonable accuracy.

For unit trains, direct costs represent nearly one half of the railways' variable costs (costs that vary with the amount of traffic).

The direct costs used in the costing model are summarized in Exhibit 7-8.

Indirect variable costs were estimated by using the costing model mentioned earlier. The model was used to "attribute" certain common railway expenses to performance (output) units and then apply the unit costs derived in this manner to the traffic in question. Indirect costs include, for example, such costs as the maintenance and depreciation of the common roadbed or signals. These costs have to be distributed among all of the trains that make use of common facilities.

Not all of the common systems costs reported by railways are allocated to performance units. Only those considered *variable* with additional traffic are allocated to that traffic. A certain part of the railway expenses are considered *fixed.*

In order to cover the railways' fixed costs a "markup" was applied to the total of direct and allocated variable costs. This "markup" covered:

- those costs in the various traffic-related accounts that are not considered to vary with traffic (i.e., the costs would be incurred even if there was no traffic at all on the railways' system).
- railways' losses related to the traffic forced upon them by legal requirements, such as Western Canadian Grain traffic.

The "markups" were determined for the entire *profitable* traffic of the railways, i.e., the traffic that excludes Western Grain and passenger traffic. It was found that in order to achieve a rate of return of 19.2 percent on their investment (allowed by the Canadian Transport Commission in 1978), the railways would have to apply markups in excess of 40 percent to their variable costs:

In fact, the railways do not achieve the indicated rate of return. For that reason, the markups shown above would provide the railways with a profit that is greater than the average profit that they presently derive from all of their profitable traffic combined.

7.3.3 Rail Costs Vs. Rates

In setting their rates railways follow the principles of competitive market costing. A railway would estimate the total costs resulting from the "next best" transportation alternative and the relative levels of convenience to the shippers and consignees offered by the competing alternatives. If the railway believes that the customer would see a difference in convenience between the two alternatives it would try to attach a price to it, using its best judgment.

In the case of aggregate traffic the "next best" competing transportation mode is direct trucking from the production site to the customer. In setting a rate the railways may consider that in the judgment of a decision-maker who would have to choose between adopting a transportation system based on rail or truck transportation, the latter would appear more convenient for the following reasons:

- trucking maintains the direct relations between producer and customer without the insertion of an elaborate system of terminals that, basically, represent a wholesale function
- trucking is a highly competitive business that ensures reasonably low rate levels; conversely, in the rail system, once established, the customer would be "captive" to the railways in the long term regarding both rates and service

EXHIBIT 7–8
ESTIMATED DIRECT RAIL COSTS[1]

(constant 1979 dollars)	
Fuel: $/horsepower-hour[2]	$ 0.0375
Crew (4 men): $/crew day[3]	$297.25
Equipment:	
$/locomotive day	$527.30
$/car day	$ 25.51

[1] Unit costs estimated by Consultants)

[2] Based on 0.23 litres of diesel fuel per horsepower-hour, at 16.5 cents/litre.

[3] Crew consists of: Engineer $61.47 per day
Brakemen $93.40 per day (2 men)
Conductor $53.00 per day
A contingency of 10% has been added (possible deadheading, exceeded book-rest periods, etc.), and 30% has been included for benefits.

[4] • *Daily locomotive costs* were based on a capital cost of $900,000 (1979), a capital recovery factor over 25 years of 19.4%, 365 operating days, and 10% extra costs for spares.
• *Daily car costs* were based on $45,000 (1979) gondola cars with rotary couplings, a capital recovery factor over 20 years of 12% with only 230 operating days and 10% extra costs for spares.

- the rail transportation alternative requires large capital investments in terminals by industry; conversely the trucking alternative requires investment in a freeway by the Province which might be easier to fund, particularly since the transportation system would serve the objectives of the Province.

The railway would attach a value to these factors and therefore, it is likely that a rate could be negotiated with them that would result in a total delivered price of aggregates significantly lower than the delivered price by truck.

However, the rail transportation costs calculated in this study, including the markups, are considered *minimum rates* that may be charged by the railways. These rates would still provide the railways with a rate of return significantly higher than their present system-

EXHIBIT 7–9
ESTIMATED MINIMUM RAIL RATES, TO TORONTO

($/tonne)

	LOADING TERMINAL:		LOOP TRACK(3)			CONVENTIONAL	
	RECEIVING TERMINAL:		LOOP TRACK(3)			CONVENTIONAL	
	Annual Volume (million tonnes):		20.0	11.0	9.0	3.2–6.4(2)	1.6–3.2(1)
		km					
Saugeen–Brampton	CN	170	2.65	—	—		
	CP	125	2.00	—	—		
	DT(4) (CN)	125	2.10	—	—		
	DT(4) (CP)	125	1.80	1.80	—		
Saugeen–North Toronto	CN	185	2.85	3.00	—		
	DT(4) (CN)	150	2.30	2.30	—		
Saugeen–Pickering	CP	205	2.75	—	—		
	DT(4) (CP)	187	2.35	2.35	—		
Saugeen–Toronto (Small Terminal)	CN	198	—	—	—	3.45	3.60
Little Current–North Toronto	CP	490	—	—	5.85		
Midland–North Toronto	CP	145	—	—	2.25		

(1) One-shift operation
(2) Two-shift operation
(3) Three-shift operation
(4) DT: Double Track, jointly used by CN and CP

EXHIBIT 7–10
ESTIMATED MINIMUM RAIL RATES, TO LONDON, WINDSOR, SARNIA

($/tonne)

	LOADING TERMINAL:		CONVENTIONAL(2)		CONVENTIONAL	
	RECEIVING TERMINAL:		LOOP TRACK(3)		CONVENTIONAL	
	Annual Volume (million tonnes):		6.0	4.0	3.2–6.4(2)	0.8–3.2(1)
		km				
Saugeen–London	CN	135	2.70	2.90	—	—
Saugeen–London (Small Terminal)	CN	148	—	—	3.30	3.45
Saugeen–Windsor	CN	345	—	—	5.35	5.50
Saugeen–Sarnia	CN	265	—	—	—	5.00

(1) One-shift operation
(2) Two-shift operation
(3) Three-shift operation

wide rate of return, even if only the profitable sectors of their traffic were considered (i.e., no grain and passenger traffic) and the losses incurred in the transportation of grain were actually considered as an expense. The costs derived in this study can therefore be considered reasonable representations of minimum rates.

The *maximum rates* would be represented by higher figures: these rates could result in a delivered price of aggregates approaching those resulting from transportation by truck. The appropriate margin would be estimated by the railways at the time of negotiations.

The minimum rail rates as calculated in the study for each line and railway are summarized in Exhibits 7-9 and 7-10. The overall minimum rates are shown graphically against distance in Exhibit 7-11. The rates include a "capital surcharge" applied to compensate the railways for the necessary capital costs of upgrading certain parts of their system to accommodate the aggregate traffic.

These "surcharges" are discussed in the next part of this Chapter.

7.4 COSTS OF RAILWAY TRACK IMPROVEMENTS

7.4.1 Costs to the Railways

The large volume of aggregate traffic would require the replacement of existing rails with heavier rail on all branch line sections, the reconstruction of bridges, improvement of signalling and the construction of passing tracks. The costs of these improvements would be borne by the railways and have been estimated as shown below.

	Cost of Rail Improvements (million $)		Annual Volume (million tonnes)	Capital "Surcharge" ($/tonne)
	Capital (a)	Annual (b) = 0.192x(a)	(c)	(b)/(c)
Saugeen-Toronto (CP)	21.9	4.20	20.0	0.21
Saugeen-Toronto (CN)	21.6	4.15	20.0	0.21
			11.0	0.37
Saugeen-London (CN)	14.6	2.80	6.0	0.47
			4.0	0.70
Midland-Toronto (CP)	11.9	2.28	9.0	0.23
Little Current-Toronto (CP)	33.4	6.40	9.0	0.71

In order to recover these costs the railways would probably charge the return on their entire investment to the aggregate traffic at a rate of 19.2 percent. This was the rate accepted by the Canadian Transport Commission in the calculation of subsidy payments in 1978.

7.4.2 Government Contributions to Rail Line Improvements and Double Tracking of Line

To transport a total of 40 million tonnes of mineral aggregates from the Saugeen area to the Toronto area 20 million tonnes would have to be carried by each of the two railways, each using 12 trains daily in the loaded direction and 12 empty trains in the opposite direction.

This would likely require the construction of grade separations at many existing road/rail crossings. There are no firm policies established that dictate when these are required. Using best judgment and average costs for typical grade separation projects their total capital costs were estimated to be $71 million. These costs would be borne by governments.

Assuming depreciation over 25 years, a government interest rate of 12 percent and an inflation rate of 8 percent, the annual charge would be 6.7 percent of the capital cost, i.e., $4.7 million in 1979 dollars. This amount would have to be recovered in some form by the sponsoring government. It is equivalent to an additional cost of approximately 12 cents per tonne of aggregate.

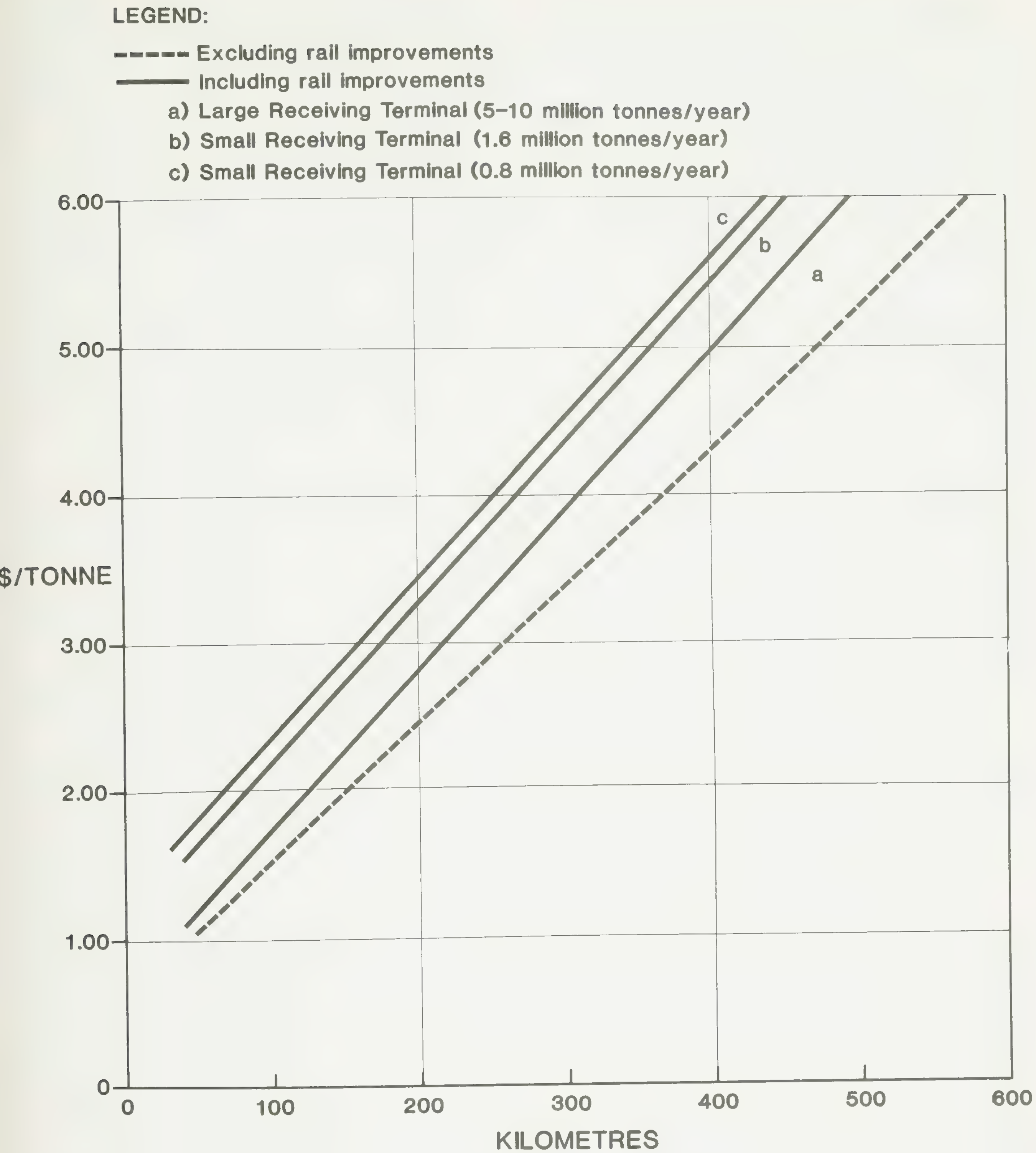
An alternative to using two separate rail lines which pass through many existing communities would be to *double track and partially relocate* the existing CP line between Durham and Brampton. This line would carry the entire volume of 40 million tonnes of aggregates, with *both railways operating on the line.*

The capital costs of the relocation and double tracking was estimated to be $82 million. Significantly fewer grade separations would be required and their costs have been included. In order to make this alternative comparable with the previous option it was assumed that the cost of double tracking would be borne by government. In that case the annual cost of capital would be 6.7 percent as before, i.e., $5.5 million or approximately 14 cents per tonne, based on 40 million tonnes per year. This compares with 12 cents for grade separations on two existing railway lines. Thus, the net additional cost of a partly relocated double track line in terms of government expenditures would be only 2 cents per tonne.

More significantly, however, there would be no need for rail improvements on the C.N. line and the improvements on the C.P. line that would be paid in the first alternative by the railway would now be paid by government. The rail haul would also become less expensive for both railways: the line haul route to Brampton would be shorter for C.N. since it would now use the C.P. right of way and the route to Pickering would be shorter for C.P. which could now use the C.N. bypass north of Toronto.

As a result, at the 40 million tonne level, the rail rates would decrease by 20 to 55 cents. There would also be some reductions in operating costs due to the higher speeds on the double-track line which, however, are relatively small and might be ignored.

A total saving of 20 to 55 cents in rail rates less a net cost for the double-track line of 2 cents would result in total savings ranging from 18 to 53 cents per tonne.



ESTIMATED MINIMUM RAIL RATES

7–11

7.4.3 Total Rail Transportation Charges

The recovery of capital expenditures by the railways, assumed to be included in the rates, is included in the rate estimates of Exhibits 7-9 through 7-11. These expenditures would only be incurred by the railways for rail line upgrading if two separate existing lines were used by the two railways. Governments would still pay for grade separations.

If a single, completely double tracked and partially relocated line was used by both railways, it was assumed that all the capital expenditures related to that line would be borne by government and the rail rates would not include any cost elements on that account. This assumption is reflected in Exhibits 7-9 through 7-11.

In order to derive the total delivered prices of mineral aggregates, the recovery of government expenditures must also be considered. Governments can recover the cost of rail line construction and improvements in several ways. It was assumed in this study that, to recover the investment in the rail lines and grade separations, the sponsoring government would impose some form of percentage levy on the price of aggregates which would be passed on to the consumers. This levy is included in the final prices of delivered aggregate calculated in Chapter 8.

7.5 DESCRIPTION AND COSTING OF SHIPS

7.5.1 Description of Ships

The ship routes examined in the study were described in Chapter 6. All of these routes start from *Manitoulin Island*, with the following destinations:

- Midland
- Owen Sound
- Sarnia
- Windsor
- Toronto

For the purpose of evaluation a port location was selected from several options in South Bay on the south shore of Manitoulin Island. This location faces Georgian Bay directly and appears to be also convenient from the point of view of land access from nearby potential quarry sites.

The characteristics of the routes are summarized below, using certain assumptions. With regard to ship speed a cruising speed of 22.5 kilometres per hour was used. It was assumed that the time required for loading the ships would be approximately 13 hours with 11 hours for unloading. These times include the time required for the ships to maneuver in and out of the harbours, docking time, waiting time and other incidental time requirements.

The following are the characteristics of the routes:

From Manitoulin to:	One-Way Distance (km)	Round Trip Sailing Time (days)	Total Round Trip Time (days)
Midland	217	1.0	2.0
Owen Sound	217	1.0	2.0
Sarnia	303	1.5	2.5
Windsor	402	2.0	3.0
Toronto	884	4.0	6.0

The times shown above include an allowance for slower sailing in the St. Clair River and a 12 hour passage each way through the Welland Canal where appropriate.

The basic type of ship considered for the mineral aggregate traffic would be a new 222 metre (730 ft.) self-unloader. Such ships are being built to approximately uniform specifications and represent the maximum size that can pass through the locks of the Seaway.

The maximum carrying capacity of these ships is approximately 32,400 metric tonnes at a draft of 9.15 metres (30 ft.). The full draft can only be utilized on the lakes; when entering the St. Clair River or the Welland Canal, the draft is lower and therefore, the carrying capacity of the ships must be reduced as follows:

	Draft, metres (ft.)	Aggregate Carrying Capacity, metric tonnes
Lake Huron/Georgian Bay	9.15 (30)	32,400
St. Clair River	8.23 (27)	28,200
Welland Canal	7.92 (26)	26,700

Self-unloaders are loaded from a shore-based loader at the loading port. They are unloaded by unloading equipment carried on the vessel itself. Thus, self-unloaders do not require any mechanical unloading equipment on shore; all they require is a dock and adequate space for stockpiling the unloaded materials.

The self-unloaders considered in this study are powered by approximately 10,000 horsepower diesel engines. These engines use so-called "intermediate" fuels which consist of approximately 80% heavy oil and 20% diesel oil. In addition to the main engines, the ships also use diesel oil for auxiliary services on board.

An alternate ship size: a 300-metre (1000 ft.) self-unloading laker was also evaluated and compared with the standard 222 metre ship in broad terms. Whereas 300 metre ships have significant economic advantages for certain types of traffic, their main disadvantage is that they are locked into the Upper Great Lakes since they cannot pass through the seaway.

7.5.2 Costing of Shipping

The costs of water-borne transportation are discussed under four headings:

- Capital Costs
- Fuel Costs
- Other Operating Costs
- Tolls.

The *capital cost* of a new 222 metre self-unloader with no oceangoing capability was estimated to be 32.7 million dollars if delivered in 1979. Assuming that the Federal Government pays an 8% subsidy to a Canadian ship builder, the cost to the ship owner would be 31.0 million dollars.

The Federal Government is presently paying a 20 percent subsidy which is, however, expected to be reduced to 8% in the future. There is a degree of uncertainty regarding this change and there is a possibility that ship building subsidies in future years, may, in fact, be higher than 8%. In that case, the capital costs to the ship owner would be lower.

Assumptions were made for the capital cost calculations regarding inflation, interest rates and returns on investment as follows:

– Annual inflation rate:	8%
– Average rate of return on investment:	18%
– Depreciation period:	20 years
– Initial annual capital charge (capital portion of cost):	12% of investment

The assumed inflation and interest rates are internally consistent. This means that if inflation were to decrease substantially, so would interest rates.

It was found that if the capital part of the transportation rate was increased every year by the rate of inflation it would produce a rate of return equal to 18%.

The 18% return would be divided between loan interest and return on equity, depending on the debt/equity ratio chosen.

All calculations were based on the economic life of 20 years for the ship with no salvage value at the end. In physical reality, ships often last much longer and if they do, this represents an additional bonus to the ship owners, even after the expenditures for refurbishing after 20 years.

A significant negative cost element (saving) is the Capital Cost Allowance for ships allowed by the Income Tax Act. Accordingly, a new ship can be depreciated in three years for tax purposes. The cost savings accruing from savings only occur if a company has other profitable and taxable business against which the tax savings could be applied.

The initial tax savings, if annualized over the 20-year life of the ship would reduce the annual capital costs by approximately 20%. Thus, the original annual amount of 12% for capital charges could be reduced to 9.6%.

In summary, the initial capital cost of a 222-metre self unloader in the first year of operation would be 9.6% of its original cost of 31 million dollars, i.e., *2.98 million dollars*. This amount would increase by the rate of inflation every year.

Since the shipping season assumed in the study consists of 245 days, the average daily capital cost of a ship would be $2,980,000/245 = $12,200.

The cost of the *intermediate fuel* (mixture of heavy oil and diesel oil) used by the self-unloaders varies among companies, depending on the individual contracts they have with oil suppliers. There is no Provincial fuel tax or Federal excise tax on fuel for Canadian domestic ships. An average price of 12¢ per litre (55¢ per gal.) appeared to be a reasonable average figure for 1979.

The fuel consumption of the 222 m ship assumed by the study team was 200 barrels (32,000 litres) per day while cruising, and 40 barrels (6,400 litres) per day in port or when passing through the Welland Canal.

Other operating costs included crew costs, the costs of food and supplies for the crew, the costs of supplies for the ship, maintenance costs, ship insurance and other miscellaneous items. Aggregated in a single number, the average was estimated by the study to be $7,200 per day in 1979 terms.

Insurance costs vary, depending on the company. An average amount was included in the cost above. All the costs were calculated for a 245 day season, with the crews laid off for the rest of the year.

There is a *lockage fee* of 7¢/Gross Registered Ton for passing through the Welland Canal. This is equivalent to $2,800 per round trip. In addition, there is a 31¢ per tonne *Seaway toll* for mineral aggregates passing through the Welland Canal. These costs are passed on directly to the shipper of the goods.

The costs are summarized in Exhibit 7-12. As shown in Line (h) of the Table, a 5% markup was applied to the final transportation cost figure (excluding tolls) to provide for administrative costs and contributions to other overheads for the carrier.

Stevedoring costs in the ports are not included, since these are included in the terminal cost elements of the total transportation costs.

The costs, including estimates for a reasonable rate of return, indicate the *minimum revenue requirements* that ship owners may be expected to consider in quoting rates for the transportation of mineral aggregates. They are predicated on the following conditions:

- Long-term contracts would be signed by a carrier and shippers of aggregates with a guaranteed minimum volume for at least five years or, preferably, ten years with possible clauses of re-negotiation after five years.
- Escalation clauses would be built into the contract to be applied to a guaranteed rate; the rate of escalation would depend on some economic price indicators such as the Consumer Price Index, or the Labour Wage Index. For the sake of simplicity it was assumed that the same escalation would be applied to both the capital and the operating portion of the rates.

As the result of long term contracts, ship owners would build ships specifically for the mineral aggregate traffic, thereby reducing their risks and making lower rates possible.

EXHIBIT 7–12
COSTING OF SHIP ROUND TRIPS

(costs in constant 1979 dollars)

		DESTINATION FROM MANITOULIN ISLAND TO:			
		Midland	Sarnia	Windsor	Toronto
(a)	Days Sailing	1.0	1.5	2.0	4.0
(b)	Days in Port[1]	1.0	1.0	1.0	2.0
(c)	Total Days	2.0	2.5	3.0	6.0
(d)	Capital Cost: 12,200 x c =	$24,400	$30,500	$36,600	$ 73,200
	Fuel Consumption (litres):				
	– Sailing 31,800 x a	31,800	47,700	63,600	127,200
	– In Port 6,400 x b	6,400	6,400	6,400	12,800
(e)	Total Litres	38,200	54,100	70,000	140,000
(f)	Fuel Cost: 0.121 x e =	$ 4,620	$ 6,545	$ 8,470	$ 16,940
(g)	Crew + Other Operating Costs[3]: 7,200 x c =	$14,400	$18,000	$21,600	$ 43,200
(h)	Total Round Trip Costs[4]	$45,600	$57,800	$70,000	$140,000
(i)	Tonnes per Trip	32,400	28,200	28,200	26,700
(k)	Seaway Tolls, $/tonne	—	—	—	$0.42
(l)	Minimum Rate in $/tonne:[5] (h/i) + k =	$1.40	$2.05	$2.50	$5.65

NOTE: All costs estimated by Consultants. Rates represent minimum rates.
(1) Or in Welland Canal
(2) Also applies to Owen Sound
(3) Food, supplies, maintenance, ship insurance and other costs
(4) 5% for administration. "Cost" includes profit (ROI). h = 1.05 x (d + f + g)
(5) Rounded to nearest 5 cents
All tonnage data are in metric tonnes

7.6 ASSESSMENT OF PIPELINE

7.6.1 Assessment

Transportation of mineral aggregates by pipeline was assessed in broad terms prior to deciding whether a full scale study was justified. This two stage approach was used because pipeline transportation of mineral aggregates over more than 100 kilometres must be regarded as a new technology that would have to be supported by more research or practical experience before recommending it as a practically feasible alternative.

The purpose of the preliminary assessment was to determine whether further theoretical and physical research should be recommended at the present state of the art.

The following were the specifications for the pipeline subjected to preliminary assessment:

- Location: Saugeen to Brampton
- Length: 105 kilometres
- Annual throughput: 9 million metric tonnes
- Material: sand and gravel
- Maximum particle size: 50 mm (2 inches)
- Percent of fines (less than 6.2 mm): 50%

The principal characteristics of the pipeline that could theoretically comply with these specifications, at the approximately lowest overall cost, would be as follows:

- Diameter: 760 mm (30 inches)
- Number of pumping stations: 10
- Total power requirements: 100,000 kw
- Mixture of solids and water: 17.2% solids by volume (35% by weight)
- Water requirements: 48,000 litres (10,500 gal. per minute)
- Capital costs: $220 million
- Time of operation: 8 months (5500 hours)

Approximately 35 percent of the capital cost is for the construction of the pipe, the remainder of the cost is for the construction of the pumping stations.

The pipeline would operate 8 months a year or 5,500 hours. Thus, the energy consumption would be 550 million kilowatt-hours. Electrical power would be used to drive the pumps.

The energy requirements would be very high in comparison with other modes of transport. Whereas the pipeline would require more than 80 horsepower-hours per tonne, conventional rail transportation would require approximately 6 horsepower-hours per tonne. One of the reasons for this large difference is the amount of water that has to be transported: it repre-

sents approximately five times the volume of the aggregates.

The water requirement would thus be very high: approximately 48,000 litres (10,500 gallons) per minute. This amount would have to be provided in the Saugeen area and its cost has not been included in the calculations. The water would be delivered to the Brampton area which already has adequate water supply. Water disposal would therefore further add to the costs.

The annual capital charges of the pipeline and right-of-way, assuming a 20-year life, would be $28.6 million. The assumption of a 20-year life is highly optimistic and actual capital costs could easily be as high as 1.5 times the amount shown. The annual cost of energy at 2 cents/kilowatt-hour would be $11 million.

The transportation cost per tonne, based only on these two cost components would be $4.40. This excludes operating costs and the costs of the terminals at both ends of the pipeline. There is no precedent to estimate operating costs for a 105 kilometre solid pipeline: if a broad estimate of 60 cents* per tonne is assumed, the *line haul* cost of transporting aggregates by pipeline would be at least $5.00 per metric tonne, even with the most optimistic assumption of physical life for the pipe.

This compares with an equivalent rail rate of $2.00 per metric tonne. The costs of terminal handling are not included in this comparison in either case; it can be assumed, in broad terms, that terminal handling costs and charges would be similar for both pipeline and the rail haul.

Thus, it can be concluded that pipeline transportation of mineral aggregates does not appear to be feasible either on economic grounds or in terms of energy efficiency. It is however, the least disruptive from an environmental point of view as long as breaks in the pipeline do not occur too often.

The risks of the latter are discussed briefly below.

7.6.2 Technical Concerns

The abrasive characteristic of material that includes particle sizes up to 50 mm is an unknown factor. The construction of a pipeline to withstand the wear and tear represented by mineral aggregates of such size would have to be determined experimentally in the course of a thorough research program before practical application of an aggregate pipeline could be safely recommended.

A relatively short (about 10 km) pipeline to transport sand (tailings) is in operation at the Syncrude Plant in Alberta. However, the largest particle size of this material is 1.2 mm (16 mesh), as opposed to 50 mm under consideration here. Also, the pipe is about 10 km long instead of 105 and is not buried under farms and other properties in a densely populated area.

Longer pipelines that are in operation carry coal and iron ore that are ground to much finer particle sizes than even the sand mentioned above. For example, particle sizes of iron ore transported by pipeline could be as low as 350 mesh which is about 1/25th of a millimeter, i.e., less than one thousandth of the maximum particle sizes of gravel. These materials cannot be technically compared with each other.

7.6.3 Conclusion

The transportation of mineral aggregates by pipeline is not feasible at the present state of technology. The alternative must be rejected on the basis of economics, energy consumption, and technical uncertainty.

If pipeline transportation of solid materials was favoured over rail transportation over long distances in certain instances on environmental grounds, this mode of transport would have to gain wider acceptance to replace rail transport for such commodities as coal or iron ore before it could be considered for mineral aggregates. The technological problems related to the pipeline transportation of coal and iron ore are much smaller. It is reasonable therefore to recommend that research leading to the development of a mineral aggregate pipeline transportation system should be undertaken only if a perceivable trend develops that would see increasing volumes of other solid commodities switch from rail to pipeline transportation.

7.7 DESCRIPTION AND COSTING OF TERMINALS

The loading and unloading of unit trains and of ships require special handling terminals. These include appropriate machinery and equipment to move mineral aggregates from one mode of transport to a stockpile and from a stockpile to another mode of transport.

Five bulk terminals have been examined and costed in the study:

- rail loading terminals
- rail unloading terminals
- ship loading terminals
- ship-to-rail transfer terminals
- ship-to-truck unloading terminals.

In order to ensure flexibility it was assumed that the terminals would have room for stockpiles that can hold approximately 10 percent of the annual throughput. About 12 different products would have to be kept in inventory all the time: half of these are responsible for most of the business. The stockpiles at the receiving terminals would also serve as supplies for the winter when line haul transportation is at a standstill.

* *A paper presented at the Third Annual Symposium on Transport and Handling of Minerals (Vancouver 1979) by J.D. Scott, D.E. Taylor and A.M. Scott on the "Transportation of Oil Sands Tailings over Long Distances" indicates an operating cost of 0.4 cents/-tonne-km excluding energy. This is for an oilsand tailing pipeline carrying maximum particle sizes equal to 1/40th of those under consideration here and assuming a 3½ year life for the pipe that has to be rotated 90 degrees every year (clearly impossible for a 105-mile buried aggregate pipeline).*

7.7.1 Rail Loading Terminals

The rail loading terminals would be associated with aggregate processing plants. Aggregates would be transported from the excavation site to the processing plant by truck. There, the material would be dumped on a conveyor which would carry it into the plant. Processed material would be stored in the yard area in a series of stockpiles. A reclaimer would move on rail along the stockpiles, pick up the desired material and transfer it to a loadout conveyor. The loadout conveyor would carry the material to overhead bins designed to hold limited amounts of material. The unit train would move under these bins from which the material would drop into the cars.

A loop track would surround the entire terminal so that the locomotives would not have to be uncoupled from the train during the loading process. This would speed up the operation significantly. During the loading process the locomotives would move the train one car at a time.

Such terminals were found to be economical for annual volumes in excess of approximately 7 to 8 million tonnes.

For smaller volumes the loop track would be omitted and railway cars would be uncoupled and moved in groups by a local switching locomotive.

7.7.2 Rail Unloading Terminals

Large rail unloading terminals would be used to unload unit trains. Similar to the loading terminals, they would also have a loop track. The train would be moved by an "indexer" through a rotary dumper which would rotate each car along a longitudinal axis and dump its contents through the top of the car. Because of the special position of the couplings the train would not have to be uncoupled for this operation.

From the dumper the material would be transferred to stockpiles. From the stockpiles the material would be reclaimed and carried by conveyor to overhead bins from which trucks would be loaded. Trucks would be weighed on their way out.

These terminals were found to be economical above annual throughput volumes of 5 to 6 million tonnes.

For smaller volumes a different type of terminal would be more economical, requiring a different type of rail car. In a smaller terminal the trains would be uncoupled and the cars would be moved by a switching locomotive in groups over the opening of pits. The cars suited for this operation have hoppers at the bottom which are opened up for dumping the material into the pits. A "shaker" would shake the cars to ensure that all of the material is removed.

From the pits, conveyors would carry the material into stockpiles. From the stockpiles the material would be picked up by trucks with the assistance of mobile equipment, so-called front-end loaders.

Similarly to the rail loading terminals the ship loading terminals would be associated with processing plants. In these terminals the material would be loaded out through ship loaders. These are towers moving on rails along the docked ship from which the material is loaded into the hold of the ship.

7.7.3 Ship-to-Rail Transfer Terminal

The self-unloading ships would dump the aggregates on a conveyor on shore which would stockpile the material through a so-called stacker: a device moving on rails. The material would be loaded out in the same way as from a rail loading terminal.

EXHIBIT 7–13
COSTS OF RAIL LOADING TERMINALS

(million $)

(a)	Annual Throughput (million tonnes):	1.6	3.2	5.0(3)	10.0(3)	20.0(3)
	Capital Investments(4):					
	– Cost of plant	3.9	3.9	12.9	14.3	26.0
	– Present value of future replacements	0.4	0.4	0.9	1.2	2.2
	– Land cost(1)	(2)	(2)	0.5	0.5	0.5
(b)	Total	4.3	4.3	14.3	16.0	28.7
(c)	Annual Capital Cost and Local Taxes: (c) = 0.13 x (b)	0.56	0.56	1.86	2.08	3.73
(d)	Annual Operating Cost(4)	0.24	0.39	0.70	0.85	1.32
(e)	Total Annual Costs: (e) = (c) + (d)	0.80	0.95	2.56	2.93	5.05
(f)	Cost Per Tonne: (f) = (e)/(a)	$0.50	$0.30	$0.50	$0.30	$0.25

(1) $5,000 per acre
(2) Included in production site
(3) Loop track
(4) Attributed to loading operation only

7.7.4 Ship-to-Truck Transfer Terminal

The unloading of the ship at this terminal would be similar to the unloading at a ship-to-rail unloading terminal. Trucks would be loaded using front-end loaders.

7.7.5 Costing of Terminals

After detailed concepts had been developed for the terminals, their capital and operating costs were estimated. They are summarized in Exhibits 7-13 through 7-17.

Annual capital costs were calculated by using the following assumptions:

- An expected rate of return of 18 percent, including debt and equity.
- An economic life of 20 years for the facilities.
- Revenues increasing at an annual inflation rate of 8 percent.

EXHIBIT 7–14
COSTS OF RAIL RECEIVING TERMINALS

(million $)

(a)	Annual Throughput (million tonnes):	0.8	1.6	5.0[3]	10.0[3]
	Capital Investments:				
	– Cost of plant	4.0	5.1	31.9	34.1
	– Present value of future replacements	0.6	0.6	2.6	3.0
	– Land cost[1]	0.5[2]	0.7[2]	4.3[2]	4.3[2]
(b)	Total	5.1	6.4	38.8	41.4
(c)	Annual Capital Cost and Local Taxes: (c) = 0.13 x (b)	0.66	0.83	5.04	5.38
(d)	Annual Operating Cost	0.62	0.98	1.52	1.67
(e)	Total Annual Costs: (e) = (c) + (d)	1.28	1.81	6.56	7.05
(f)	Cost Per Tonne: (f) = (e)/(a)	$1.60	$1.13	$1.31	$0.70
	for Toronto[1]:	$1.76	$1.24	$1.53	$0.81

[1] $25,000 per acre in Windsor, Sarnia, London areas
$75,000 per acre in Toronto area

[2] Multiply by 3 for Toronto area

[3] Loop track, rotary dumper and reclaimer/overhead loadout

EXHIBIT 7–15
COSTS OF SHIP LOADING TERMINALS

(million $)

(a)	Annual Throughput (million tonnes):	5.0	10.0	20.0
	Capital Investments[2]:			
	– Cost of plant	23.0	24.0	45.0
	– Present value of future replacements	1.3	1.4	2.8
	– Land cost[1]	0.2	0.2	0.2
	– Marine work	1.5	1.5	1.5
(b)	Total	26.0	27.1	49.5
(c)	Annual Capital Cost and Local Taxes: (c) = 0.13 x (b)	3.38	3.52	6.43
(d)	Annual Operating Cost[2]	0.85	1.02	1.58
(e)	Total Annual Costs: (e) = (c) + (d)	4.23	4.54	8.01
(f)	Cost Per Tonne: (f) = (e)/(a)	$0.85	$0.45	$0.40
(g)	Loadout Cost per Tonne			

[1] $25,000 per acre

[2] Attributed to loading operation only

- Return on investment (profit) accrued and interest payments made at the end of the year, with revenues accruing during the year. This cash flow was assumed to cover the requirements for working capital.

With these assumptions the annual cost of capital would equal 12 percent of the original investment in the initial year. As noted, this cost would increase at the rate of inflation every year, i.e., by 8 percent. Operating costs were assumed to increase at the same rate but so would revenues.

The large rail loading terminals in the Saugeen area were assumed to be combined with large processing plants which receive unprocessed aggregates from excavation sites at an average distance of 5 to 10 kilometres.

The prices of the materials in the stockpiles exclude the costs of loading into trucks, railway cars or ships, but include the costs of excavation, processing, handling up to the stockpile and the producers' return on investment.

The operations imply the most efficient handling methods appropriate to the volumes handled. Brief notes related to the methods of handling are made in the Exhibits.

The terminal costs for the rail loading and receiving terminals are also shown graphically in Exhibits 7-18 and 7-19.

7.8 SENSITIVITY OF RATES TO OIL PRICES

The sensitivity of truck, rail and ship rates to crude oil prices was tested under three assumptions:

(a) Crude oil prices will rise at the same rate as inflation.

EXHIBIT 7–16
COSTS OF SHIP/RAIL TRANSFER TERMINALS

(million $)

(a)	Annual Throughput (million tonnes):	5.0	10.0
	Capital Investments:		
	– Cost of plant	24.4	27.1
	– Present value of future replacements	1.9	2.3
	– Land cost[1]	1.5	1.5
	– Marine work	0.5	0.5
(b)	Total	28.3	31.4
(c)	Annual Capital Cost and Local Taxes: (c) = 0.13 x (b)	3.68	4.08
(d)	Annual Operating Cost	1.45	1.70
(e)	Total Annual Costs: (e) = (c) + (d)	5.13	5.78
(f)	Cost Per Tonne: (f) = (e)/(a)	$1.03	$0.58

[1] $15,000 per acre

EXHIBIT 7–17
COSTS OF SHIP/TRUCK TRANSFER TERMINALS

(million $)

(a)	Annual Throughput (million tonnes):	2.0	5.0
	Capital Investments:		
	– Cost of plant	13.0	14.0
	– Present value of future replacements	1.9	2.7
	– Land cost[1]	2.0[2]	2.0[2]
	– Marine work	2.0	2.0
(b)	Total	18.9	20.7
(c)	Annual Capital Cost and Local Taxes: (c) = 0.13 x (b)	2.46	2.69
(d)	Annual Operating Cost	1.08	1.41
(e)	Total Annual Costs: (e) = (c) + (d)	3.54	4.10
(f)	Cost Per Tonne: (f) = (e)/(a)	$1.77	$0.82
	for Toronto[2]:	$2.03	$0.92

[1] $25,000 per acre at Windsor and Sarnia, $75,000 in Toronto area.
[2] In Toronto area multiply by 3.

(b) The price of crude oil will be *twice as high* as under (a).

(c) The price of crude oil will be *three times as high* as under (a).

The average price of crude oil in Canada was $13.25 per barrel in 1979. This corresponds to Case (a). In Case (b) the price would have been $26.50. In Case (c) the price would have been $39.75.

Corresponding product prices would have been (in cents/litre):

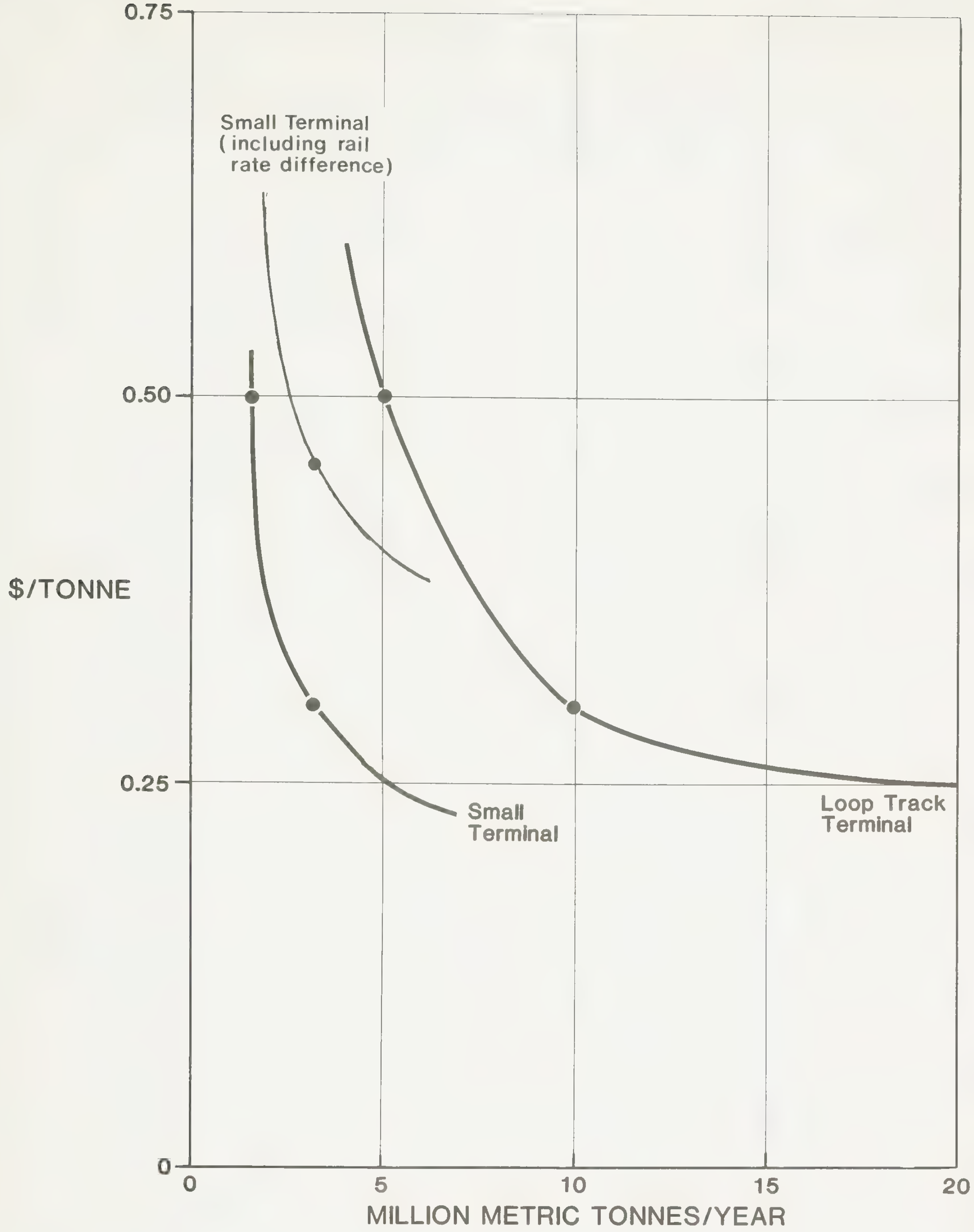
	(a)*	(b)	(c)
Diesel oil for trucks:	19.8	32.5	45.3
Diesel oil for locomotives:	16.5	26.9	37.2
Intermediate fuel for ships:	12.1	20.4	28.7

Typical changes in transportation rates would be (in $/tonne, rounded to the nearest 5¢):

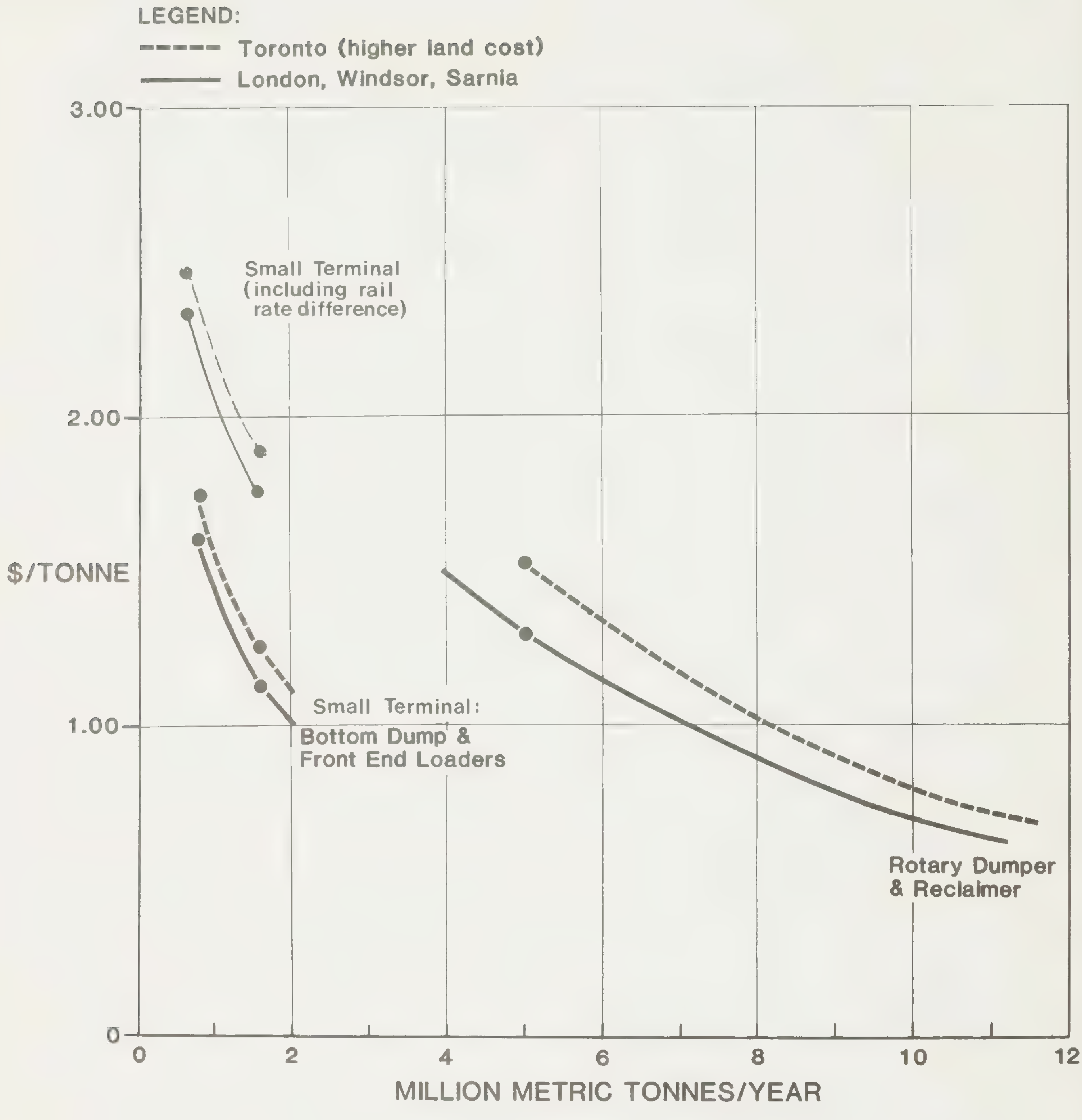
	(a)*	(b)	(c)
Distribution truck (35 km):	2.00	2.20	2.45
Rail haul (150 km):	2.30	2.55	2.80
Long distance truck haul (160 km):	7.40	8.25	9.15
Ship haul (400 km):	2.50	2.70	2.95

All the rates shown are in 1979 constant dollars and would increase in the future at the rate of inflation.

* *Used in the calculations of this study.*



RAIL LOADING TERMINAL RATES 7-18



RAIL RECEIVING TERMINAL RATES 7-19

CHAPTER 8

Economic Comparison and Shortlisting of Transportation Systems

The total transportation systems were described in Chapter 6. Chapter 7 described the individual components of the systems and their costs. This Chapter summarizes the total costs of the systems and provides a comparison of the systems on economic grounds.

The basis for the economic comparison is the "delivered price" of aggregates, including their price at the producing plant and all transportation, handling and distribution charges that are added to that price before the material is delivered to the final customer.

In this Chapter the more costly systems are eliminated from further evaluation, provided that they are not judged to have higher rankings with respect to community or environmental impacts, quality of service or fuel requirements. If a system were found to be more costly than another system but potentially more desirable by some of the other criteria, it would still be shortlisted for consideration in the final evaluation.

The final evaluation of the shortlisted systems by all criteria is presented in Chapter 9.

8.1 PRICES AT PLANT

Prices of mineral aggregates vary depending on the particular commodity, on their quality and on the plant location in relation to markets. In the producers' survey reported in Chapter 4 the producers were asked to state their prices at their plant. Their replies indicated an average price of $2.25 per metric tonne for the range of processed sand and gravel. This price included the costs of:

- extraction
- transportation to the processing plants
- processing
- stockpiling
- loading into trucks
- property rehabilitation
- sales and administration.

Each of these operations included direct operating costs as well as the costs of capital in the form of return on investment, which is the producers' profit.

Average crushed stone prices were found to be 10¢ higher, averaging $2.35 per metric tonne.

The plants that offer the prices indicated above were built some time ago when capital costs were much lower. As the result of inflation the capital cost of plants and equipment has increased significantly in recent years. The cost of land has also increased substantially and so have local taxes associated with the capital value of the land and the plant. It is estimated that a new plant with an annual production capacity of one million tonnes would have to charge approximately 40 cents per metric tonne to cover the costs of capital investments and associated costs. Assuming further that within today's price approximately 10 cents are charged to cover capital costs, the price of mineral aggregates produced by a new plant would be 30¢ higher per metric tonne than the price of aggregates produced by an old plant under competitive pressure.

Thus, an average price of $2.55 per metric tonne was assumed in the calculations for sand and gravel placed into a truck. This is the present (1979) average price of $2.25 per metric tonne plus a 30 cent surcharge due to the high capital cost of a new plant. Crushed stone would cost $2.65 per tonne.

To compute the delivered prices of aggregates transported by various methods the most convenient common starting point is the price of processed material in the original stockpile. The price at the stockpile stage would be 25 cents lower than the sales price, since this is the approximate cost of loading delivery trucks by means of front end loaders. The basic stockpile prices used in the analysis for aggregates produced in a conventional small plant were therefore $2.30 per metric tonne for sand and gravel and $2.40 per metric tonne for stone.

In the comparison of future production alternatives these prices would be valid at any of the source locations considered. Thus, in the economic comparisons it was assumed that the same prices will eventually prevail at production sites within the demand areas and at sites remote from these areas.

Large processing plants can produce processed aggregates at a lower cost than the present smaller plants. It was estimated that economies of scale would result in the following price differences:

	Difference in Capital Charges	Difference in Operating Costs	Total	Extra Cost of Trucking from Excavation (see text below)	Total Price Difference
5 million metric tonne plant:	−5¢	—	−5¢	+20¢	+15¢
10 million metric tonne plant:	−10¢	−5¢	−15¢	+30¢	+15¢
20 million metric tonne plant:	−10¢	−10¢	−20¢	+40¢	+20¢

At larger plants the area required to supply the material is larger, and therefore the distances of trucking the aggregates from the excavation to the processing facilities are longer. The costs of extra trucking exceed the savings in processing costs achieved by the economies of larger operations.

The additional trucking distance was assumed to be 5 kilometres on average for a 5 million tonne plant, increasing to 10 kilometres for a 20 million tonne plant. The extra cost of trucking would be 20 to 40 cents per tonne. Thus, the price of aggregates available from a large centralized plant was estimated to be 15 to 20 cents higher than from a smaller plant as shown in the table above.

EXHIBIT 8–1
AGGREGATE PRICES FROM PLANT STOCKPILE[2]

PLANT PRODUCTION (million tonnes per year)	SAND AND GRAVEL $/tonne	STONE[1] $/tonne
less than 5.0	2.30	2.40
5.0	2.45	2.35
10.0	2.45	2.35
20.0	2.50	—

[1] Excavation near terminal.
[2] Excludes cost of loading into trucks, rail cars or ships.

EXHIBIT 8–2
COSTS OF UNDERGROUND MINING OF STONE

(million $)		TORONTO	LONDON, WINDSOR	SARNIA
(a)	Annual Production (million tonnes)	4.5	2.0	1.3
	Depth (metres)	400	100	200
	Capital Investments:			
	– Cost of plant	34.0	14.5	13.0
	– Present value of future replacements	5.0	2.5	2.0
	– Land cost[1]	7.5	2.0	2.0
(b)	Total	46.5	19.0	17.0
(c)	Annual Capital Cost and Local Taxes: (c) = 0.13 x (b)	6.0	2.5	2.2
(d)	Annual Operating Cost	9.0	4.5	2.6
(e)	Total Annual Costs: (e) = (c) + (d)	15.0	7.0	4.8
(f)	Cost Per Tonne before Secondary Crusher: (f) = (e)/(a)	$3.35	$3.50	$3.70
(g)	Equivalent Costs for Surface Quarry[2]	$1.15	$1.25	$1.30
(h)	Estimated Price Difference between Stone Produced by Underground and Surface Extraction: (h) = (f) – (g)	$2.20	$2.25	$2.40
(i)	Estimated Price of Conventional Quarried Stone in Stockpile (from Exhibit 8–1)	$2.35[3]	$2.40	$2.40
(k)	Price of Locally Mined Stone in Stockpile: (k) = (h) + (i)	$4.55	$4.65	$4.80

[1] $75,000 per acre for Toronto, $25,000 elsewhere.
[2] Excludes terminal costs, administrative and sales costs and overheads.
[3] 5 cents less than stone produced in a smaller plant.

The large centralized plants make it possible, however, to use efficient and low-cost line haul transportation by unit trains or by large ships.

The plants and ship loading terminals on Manitoulin Island were assumed to be supplied from quarry faces very close to the plants. Thus, no extra cost was assumed for trucking stone to the plants: only the savings resulting from the economies of scale were considered.

The aggregate stockpile prices resulting from the adjustments above are summarized in Exhibit 8-1.

8.2 LOCAL UNDERGROUND MINING OF STONE

As discussed earlier, an alternative to long distance transportation of mineral aggregates would be underground mining of stone close to the markets. This source of aggregates would be environmentally more desirable than open pit extraction.

Concepts were developed in the study for the mining operations and costed. The costs were found to be higher than those of open pit extraction but lower than the combined costs of open pit extraction and long distance transportation.

The estimated prices of locally mined stone are summarized in Exhibit 8-2.

The capital and operating costs of underground mining were compared with those of quarrying the equivalent amounts of stone and the cost differences were added to the prices used for quarried stone.

Exhibit 8-2 indicates that the stockpile price of locally mined stone would be approximately twice as high as the equivalent price of quarried stone. However, underground mines could be located much closer to the customers and, therefore, substantial savings can be achieved in distribution.

The economic comparisons of the various alternatives are summarized in Section 8.3.

8.3 ECONOMIC COMPARISONS

The economic comparisons of the complete transportation systems are summarized in Exhibits 8-3 through 8-13.

8.3.1 Transportation from the Saugeen to the Toronto Area

Exhibit 8-3 shows the transportation costs of 40 million tonnes of aggregates from the Saugeen area to the Toronto area by rail on the existing rail lines and directly by truck.

In this alternative the volume would be equally di-

EXHIBIT 8–3
DELIVERED PRICES, TRANSPORTATION BY RAIL AND TRUCK, SAUGEEN–TORONTO, EXISTING RAIL LINES

(40 million tonnes/year)

	RAIL				DIRECT TRUCK
	TO BRAMPTON CP	TO BRAMPTON CN	TO N. TORONTO CN	TO PICKERING CP	
Distance (km)	125	170	185	205	160
Annual Volume (million tonnes)	10.0	10.0	10.0	10.0	Any
Aggregate Price ($)					
In Stockpile	2.50	2.50	2.50	2.50	2.30
Loading	.25	.25	.25	.25	.25
Rail Rate	2.00	2.65	2.85	2.75	
Receiving Terminal	.80	.80	.80	.80	
Truck to Customer	1.15[1]	1.15[1]	1.15[1]	1.15[1]	7.40
	6.70	7.35	7.55	7.45	9.95
Average			7.26		
Cost of Grade Separations			0.12		
			7.38		
Average Price from Local Supplier:					
FOB Plant	2.55				
Truck to Customer	2.00[2]				
	4.55				

[1] 15 km
[2] 35 km

vided between the two railways and transported from two large loading terminals to four large receiving terminals. Two receiving terminals have been assumed to be near Brampton, one north of Toronto and one near Pickering, all close to the freeway system.

The average delivered price by rail, without consideration of the cost of grade separations, would be $7.26 per tonne. The cost of grade separations would represent an additional 12 cents per tonne. This would be a government cost under present policies. It was assumed that this cost would be recovered by government in some form from the industry and would therefore be included in the delivered price of aggregate.

In total, the average delivered price of mineral aggregates in the Toronto area is predicted to be at least $7.38 per tonne if the total volume of 40 million tonnes were transported by rail from large terminals in the Saugeen area to large terminals in the Toronto area. This compares with an average delivered price of $4.55 per tonne in the present system. All prices are at 1979 levels.

Thus, the price of mineral aggregates would increase by at least $2.83 or 62 percent.

The price of material delivered by direct trucking from Saugeen is estimated to be much higher: $9.95 per tonne.

In the alternative shown in Exhibit 8-4, about 23 percent of the aggregates would be produced locally from two underground mines. One of the rail receiving terminals would therefore be omitted and it was assumed that C.N. would carry only 11 million tonnes of aggregates; C.P.'s volume of 20 million tonnes would be unchanged. However, because of C.N.'s lower volume, grade separations on their line would be no longer necessary.

The delivered price of locally mined aggregate would be only 30 percent higher than the present price. It would reduce the total "blended" average delivered aggregate price to $7.00 per tonne: a minor saving from the previous alternative.

Exhibits 8-5 and 8-6 show the impacts of the alternative of double tracking the C.P. line and carrying the entire volume of aggregates from the Saugeen area to the Toronto area on that line. Both railways would use the fully double tracked line that would contain relocated sections to avoid built-up areas.

In spite of the cost of double tracking the overall savings would be substantial.

This results from four reasons:

(a) The line haul distance would be reduced by using the C.P. alignment.

EXHIBIT 8–4
DELIVERED PRICES, RAIL TRANSPORTATION COMBINED WITH UNDERGROUND MINING, SAUGEEN–TORONTO, EXISTING RAIL LINES

(31 million tonnes/year from the Saugeen area)
(9 million tonnes/year local underground mining)

	RAIL				LOCAL UNDERGROUND MINING
	TO BRAMPTON CP	TO BRAMPTON CN	TO N. TORONTO CN	TO PICKERING CP	
Distance (km)	125		185	205	15
Annual Volume (million tonnes)	11.5		11.0	8.5	9.0
Aggregate Price ($)					
In Stockpile	2.50		2.45	2.50	4.55
Loading	.25		.30	.25	.25
Rail Rate	2.00		3.00	2.75	
Receiving Terminal	.70		.75	.95	
Truck to Customer	1.15(1)		1.15(1)	1.15(1)	1.15(1)
	6.60		7.65	7.60	5.95
Average			6.96		
Cost of Grade Separations			0.04		
			7.00		
Average Price from Local Supplier:					
FOB Plant	2.55				
Truck to Customer	2.00(2)				
	4.55				

(1) 15 km
(2) 35 km

EXHIBIT 8–5
DELIVERED PRICES, TRANSPORTATION BY RAIL AND TRUCK, SAUGEEN–TORONTO, SHARED DOUBLE-TRACK LINE

(40 million tonnes/year)

	RAIL				DIRECT TRUCK
	TO BRAMPTON CP	TO BRAMPTON CN	TO N. TORONTO CN	TO PICKERING CP	
Distance (km)	125	135	150	187	160
Annual Volume (million tonnes)	10.0	10.0	10.0	10.0	Any
Aggregate Price ($)					
In Stockpile	2.50	2.50	2.50	2.50	2.30
Loading	.25	.25	.25	.25	.25
Rail Rate	1.80	2.10	2.30	2.35	
Receiving Terminal	.80	.80	.80	.80	
Truck to Customer	1.15(1)	1.15(1)	1.15(1)	1.15(1)	7.40
	6.50	6.80	7.00	7.05	9.95
Average			6.86		
Double Track and Grade Separations			0.14		
			7.00		
Aggregate Price from Local Supplier:					
FOB Plant	2.55				
Truck to Customer	2.00(2)				
	4.55				

(1) 15 km
(2) 35 km

(b) The number of grade separations would be reduced by relocating the line from most of the urban communities to rural areas, where road crossings are fewer and road traffic volumes are lower.
(c) The costs of grade separations, where required, would be lower because of lower property costs in the rural areas.
(d) The rail construction and improvement costs would be paid by government, which requires a lower rate of return on investment than the railways.

The economically most attractive alternative would be that shown in Exhibit 8-6. In this alternative local underground mining would be combined with double-tracking the rail line. The overall average delivered price of aggregates in this alternative would be $6.76 per tonne. This would be $2.21 higher than the present price and represents a 48 percent price increase.

Exhibit 8-7 shows a comparison between the costs of a system consisting of large plants and terminals and a more conventional system in which rail shipments are made from relatively smaller terminals in the Saugeen area to a number of small terminals in the Toronto area. In this comparison it was assumed that the average trucking distance from a large terminal in the Toronto area would be 15 kilometres, but from a small terminal only 5 kilometres.

In spite of that difference, the small terminals would not be economical. The annual volumes were selected so as to ensure full train-loads throughout the year, i.e., a system that achieves maximum efficiency. Even so, the alternatives shown in the second and third columns of Exhibit 8-7 indicate higher prices than the prices that could be achieved with large terminals. It should be noted that the "small" terminals included in these alternatives would still be reasonably large in today's terms: the loading terminals would range from 1.6 to 3.2 million tonnes per year and the receiving terminals from 0.8 to 1.6 million tonnes.

If the rail terminals could be located on the premises of the customer the 5-km truck haul of aggregates from the receiving terminals to the ultimate customers would be eliminated and the small terminals would become more attractive. The last two columns of Exhibit 8-7 indicate that if a customer in the Toronto area can use approximately 3 million tonnes of aggregates per year *on its own premises* it would be less costly for such a customer to receive the material directly instead of receiving it through a large distribution termi-

nal. However, if the consumption of the customer was only 2 million tonnes per year, it would be less costly to use the large common terminal.

Thus, direct rail shipments would be limited to very large consumers of aggregates that can absorb well over 2 million tonnes within a single location such as a ready-mix, concrete product and/or asphalt plant.

The comparison shown in Exhibit 8-7 was carried out for a C.N. haul from Saugeen to a customer in the eastern part of Metropolitan Toronto—over a distance of 198 kilometres. As shown, if rail deliveries were made between small terminals, the following "surcharges" would likely be applied by the railways to the basic rate established for an equivalent haul between large terminals:

	One-shift Operation	Two-shift Operation
1) Annual volume (million tonnes)		
–Loading terminal:	1.6	3.2
–Receiving terminal:	0.8	1.6
Surcharge ($/tonne):	0.75	0.60
2) Annual volume (million tonnes)		
–Loading terminal:	1.6	3.2
–Receiving terminal:	6.0–11.5	6.0–11.5
Surcharge ($/tonne):	0.30	0.15

As indicated in Chapter 7, the rail rates from a conventional loading terminal, handling approximately 3 million tonnes of aggregate per year, would be 15 cents higher than the rates applicable to a large (10-20 million tonne) terminal. It was shown in Exhibit 8-1 that the estimated price of aggregates at a large terminal may be 20 cents higher than at a small terminal. This would indicate a small economic advantage for the small terminals. However, to produce a total of 40 million tonnes of aggregates, small plants would have to be scattered throughout the Saugeen area, connected by a rail network. The large number of terminals and rail spurs would make it difficult to plan the transportation system within the Saugeen area in a way in which the environmental impacts of the rail movements were minimized.

Conversely, if two 20 million tonne terminals were built, the haul of aggregates from the excavation sites to these terminals could be planned and designed in a way in which the environmental effects of transportation are minimized. Excavations would occur in a concentrated fashion at a relatively small number of locations at any given time. After the supplies at these locations had been exhausted, excavation would move to other sites and the previous sites and their

EXHIBIT 8–6

DELIVERED PRICES, RAIL TRANSPORTATION COMBINED WITH UNDERGROUND MINING, SAUGEEN–TORONTO, SHARED DOUBLE-TRACK RAIL LINE

(31 million tonnes/year from the Saugeen area)
(9 million tonnes/year local underground mining)

	RAIL			LOCAL UNDERGROUND MINING
	TO BRAMPTON CP CN	TO N. TORONTO CN	TO PICKERING CP	
Distance (km)	125	150	187	15
Annual Volume (million tonnes)	11.5	11.0	8.5	9.0
Aggregate Price ($)				
In Stockpile	2.50	2.45	2.50	4.55
Loading	.25	.30	.25	.25
Rail Rate	1.80	2.30	2.35	
Receiving Terminal	.70	.75	.95	
Truck to Customer	1.15(1)	1.15(1)	1.15(1)	1.15(1)
	6.40	6.95	7.20	5.95
Average		6.62		
Double Track and Grade Separations		0.14		
		6.76		

Aggregate Price from Local Supplier:	
FOB Plant	2.55
Truck to Customer	2.00(2)
	4.55

(1) 15 km
(2) 35 km

EXHIBIT 8–7
DELIVERED PRICES, TRANSPORTATION OF LOW VOLUMES, SAUGEEN–TORONTO, SMALL RAIL TERMINALS

	CENTRAL TERMINAL, N. TORONTO	CN RAIL — SMALL LOADING AND RECEIVING TERMINALS — SHORT DISTRIBUTION DISTANCE		CN RAIL — SMALL LOADING AND RECEIVING TERMINALS — ON-SITE USE[5]	
		TWO SHIFTS	ONE SHIFT	TWO SHIFTS	ONE SHIFT
Distance (km)	185	198	198	198	198
Annual Volume (million tonnes)	10.0	3.2	1.6	3.2	1.6
Aggregate Price ($)					
In Stockpile	2.50	2.30	2.30	2.30	2.30
Loading	.25	.30	.50	.30	.50
Rail Rate	2.85	3.45	3.60	3.45	3.60
Receiving Terminal	.80	1.25[4]	1.75[4]	1.00[4]	1.50[4]
Truck to Customer	1.15[1]	.70[3]	.70[3]	—	—
	7.55	8.00	8.85	7.05	7.90

Average Price from Local Supplier:	
FOB Plant	2.55
Truck to Customer	2.00[2]
	4.55

(1) 15 km
(2) 35 km
(3) 5 km
(4) Two receiving terminals each handling one half of the volumes loaded at one loading terminal.
(5) Large customers, such as concrete plants.

transportation links would be rehabilitated. For these reasons the alternative of large processing plants and loading terminals is preferable to the alternative of small plants in spite of the potential small economic advantage of the latter.

In summary, the rail alternative comprising large terminals, was shortlisted for final evaluation, without and with complementary underground mining. The option of a partly re-located, fully double-tracked line, shared by both railways, was preferred over the existing lines because of lower costs and advantages by all other criteria.

The trucking alternative was also shortlisted to indicate the upper limit of transportation costs. These would probably be used as benchmarks by the railways to determine the ranges in which they may quote rates.

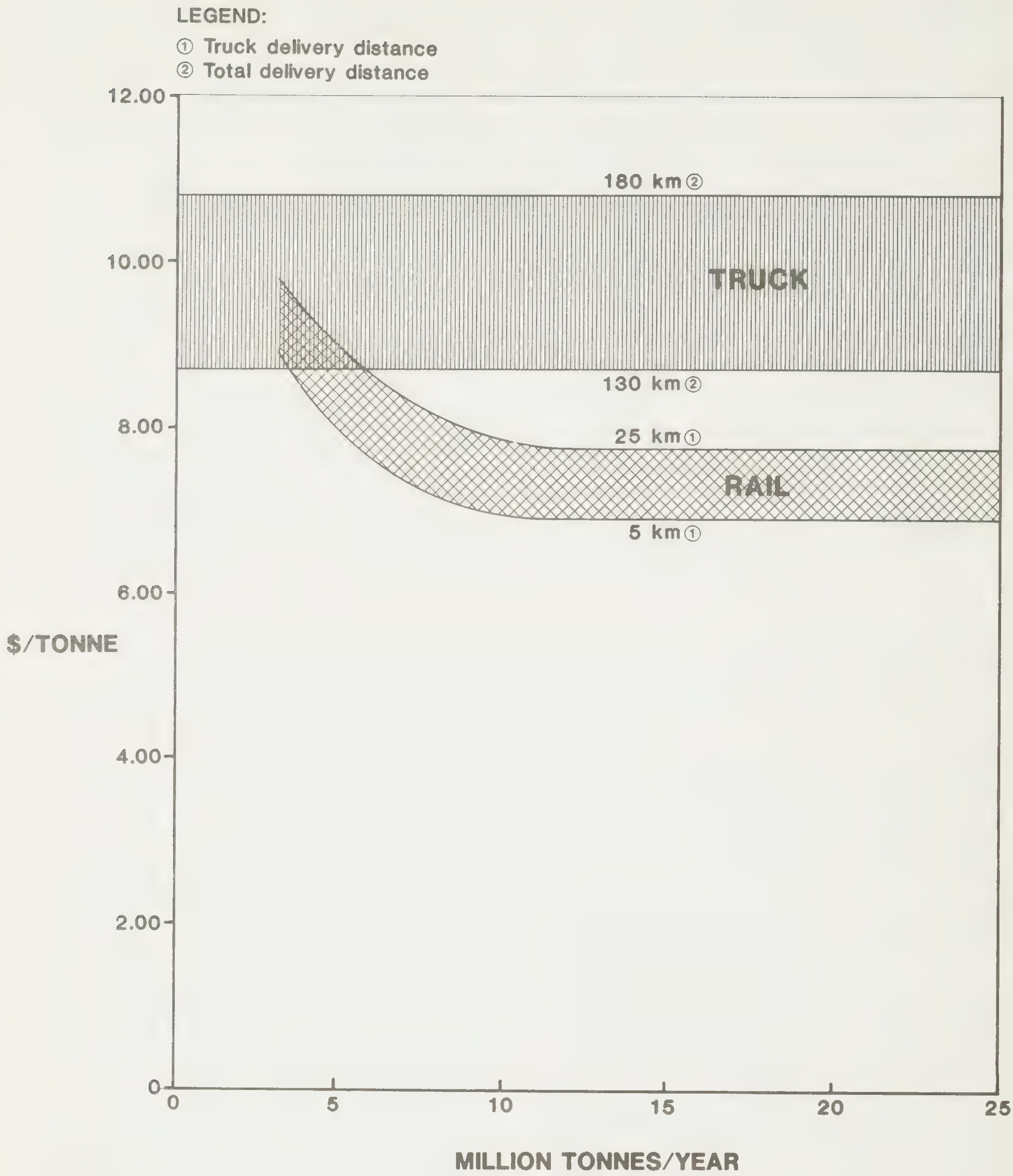
8.3.2 Transportation of Aggregates During the Transition From a Local to a Long Distance Supply System

If restrictions on the granting of new licences for aggregate extraction in the Toronto area made long distance transportation necessary the present system of local supply would gradually change to a long distance transportation system. The pace of change would be determined by the rate at which local supplies were progressively depleted.

Thus, initial transportation volumes would be smaller than those assumed in the previous analysis. The volumes would increase with the depletion of local sources and would eventually reach, or even surpass, the volume of 40 million tonnes per year assumed in the preceding evaluations.

The delivered price of aggregates would change only marginally within a range of 10 million to 40 million tonnes per year. Railway operating costs would not change, nor would the costs of the receiving terminals which would have a maximum capacity of 10 million tonnes in either system. The only difference in costs between a system supplying 10 million tonnes per year and a system supplying 40 million tonnes a year would be in the costs of the loading terminals. However, as shown in Exhibit 7-13 the cost difference would be almost negligible: about 5¢ per tonne.

It was assumed in the study that if the long distance transportation of mineral aggregates became necessary, government would build or finance the necessary rail facilities and grade separations. It would be consistent with this assumption to further assume that the full facilities necessary for the transportation of the



DELIVERED PRICE OF AGGREGATES - TORONTO AREA

8-8

final aggregate volumes would be provided from the outset even though the initial volumes may be lower.

Although the transportation of 10 million tonnes of aggregates would require only 12 trains per day instead of the 48 trains required by the transportation of 40 million tonnes, this traffic would still represent a significant change from the present traffic of only a few short trains per week on the rail lines concerned. From the point of view of impacts on residents along the rail lines a change from the present light traffic to 12 trains per day would still represent an increase in disturbance of many orders of magnitude and therefore justify the same measures as 48 trains, i.e., the relocation of significant parts of the rail line.

Grade separations may be built at a somewhat slower pace in a phased introduction of the long distance transportation system, depending on the density of traffic at various points.

It can be assumed that the cost element representing the government's expenditures on rail line construction and on grade separations in the aggregate price would not vary with transportation volumes. These costs can be recovered by government in several ways. They would probably be recovered through a form of levy on the *total* volume of aggregates produced in the Toronto area. The levy would logically be imposed on all aggregates produced in the Toronto area, not just on the volumes transported from long distances, which would already be substantially more expensive than local supplies.

Thus, it can be assumed that the cost factor representing government investments would be the same per tonne of aggregate regardless of the volume transported from long distances and, therefore, aggregate prices would not be sensitive to transportation volumes on account of that factor.

Exhibit 8-8 shows the estimated delivered prices of aggregates in the Toronto area for various annual volumes transported from the Saugeen area. The diagram shows the estimated prices of aggregates delivered by rail and by truck.

Ranges are shown for both rail and truck deliveries, depending on the location of the customer within the Toronto area. For rail deliveries, a customer who is far from the rail receiving terminal would pay more for the aggregates because of higher local trucking charges. In the direct trucking alternative a customer who is located farther from the source would also pay the trucker more for the delivery.

Exhibit 8-8 shows that the prices of aggregates delivered by truck would be independent of annual volume. The prices of aggregates delivered by rail would be practically unchanged above an annual volume of 10 million tonnes but would be higher for smaller volumes, due to higher terminal charges (see Exhibit 8-7).

At small annual volumes the price ranges for the rail and truck systems intersect each other and the relative advantage or disadvantage of rail transportation in comparison with trucking would depend on the location of the customer. For example, a customer located relatively close to the Saugeen source area (e.g., north of Brampton) but far from the nearest rail receiving terminal (e.g., from a terminal in Scarborough) could find it more economical to have aggregates delivered by truck directly from the source. As indicated in Exhibit 8-8, this would only occur if the total annual volume of aggregates delivered from long distances was relatively small and, therefore, the terminals would be small.

With four large terminals in the Toronto area the

EXHIBIT 8–9
DELIVERED PRICES, MANITOULIN ISLAND–TORONTO

(9 million tonnes/year)

	SHIP/RAIL (CP) VIA GEORGIAN BAY	ALL-SHIP VIA WELLAND CANAL	ALL RAIL (CP)
Distance (km)	217 + 145	884	490
Annual Volume (million tonnes)	9.0	9.0	9.0
Aggregate Price ($)			
In Stockpile	2.25	2.25	2.25
Loading	.45	.45	.30
Ship Rate	1.40	5.65	—
Transfer Terminal	.60	—	—
Rail Rate	2.25	—	5.85
Receiving Terminal(s)	.85	1.00	.85
Truck to Customer	1.15(1)	1.55(2)	1.15(1)
	8.95	10.90	10.40

(1) 15 km
(2) 25 km

price ranges shown in the diagram for rail and truck transportation would not intersect each other, regardless of delivery distance in the Toronto area. Thus, the prices resulting from a rail transportation system would always be lower than those resulting from direct trucking to any customer in the Toronto area.

8.3.3 Transportation from Manitoulin Island to the Toronto Area

Exhibit 8-9 is a summary of transportation costs of stone from Manitoulin Island to the Toronto area. The delivered prices are much higher than those of sand and gravel transported by rail from the Saugeen area. The price differences are even more pronounced when compared with the prices of stone produced from local underground mines.

Other factors that have to be considered in the evaluation of the transportation of aggregates from Manitoulin Island to Toronto are:

- Manitoulin Island could supply only crushed stone. Significant volumes of fine aggregates would therefore still be required in the Toronto area from other sources.
- The transportation options that include rail transportation would not have less disruptive impacts on the communities and on the environment than the rail transportation options from the Saugeen area.
- Direct ship haul to the Toronto area would require terminals on the Toronto area waterfront that would create excessive truck traffic near the terminals. This traffic would have worse impacts than the traffic experienced in the present system of local aggregate supply.

On the basis of this preliminary evaluation the alternatives of transporting stone from Manitoulin Island to the Toronto area were eliminated from further consideration.

8.3.4 Transportation from the Saugeen to the London Area

Exhibits 8-10 and 8-11 show the costs of the following transportation alternatives from the Saugeen to the London area:

(1) All aggregate needs supplied by rail.
(2) All aggregate needs supplied by truck.
(3) Two-thirds of the aggregate needs supplied from the Saugeen area by rail, one-third supplied from a local underground stone mine.

In Alternative (1), 6 million tonnes of aggregates would be shipped per year. According to the curves of Exhibit 7-18, for loading such a volume into trains in the Saugeen area, two 3 million tonne conventional loading terminals would be more economical than one 6 million tonne loop-track terminal.

Three options were costed with regard to receiving terminals:

- a single receiving terminal for the entire area
- two common use receiving terminals
- four common use receiving terminals

The options with the smaller terminals were also examined under the assumption that the terminals would be on the customers' premises (no distribution trucking required).

Exhibit 8-10 shows that the delivered prices in the alternative with a large receiving terminal would be somewhat higher than the average price that could be achieved in Toronto: $7.60 per tonne in 1979 dollars. This price would be almost twice as high than the 1979 average price of $3.90.

The conclusions regarding smaller receiving terminals were similar to those reached for the Toronto area. Except where the aggregate is used at railside, it would be more economical to use a centralized large receiving terminal for the entire volume of 6 million tonnes per year. However, if a single customer can use more than 1.5 million tonnes of aggregates per year, direct rail shipments to such a customer would be marginally more economical.

Alternative (2), i.e., direct trucking from the Saugeen to the London area, would be significantly more costly than the rail alternative.

Exhibit 8-11 shows the cost of Alternative (3): rail transportation supplemented by local underground mining. Although the price of locally mined stone would be lower than the price of aggregates transported from the Saugeen area, the overall *average* price for the system would not be much lower than the delivered price of aggregates in Alternative (1), in which all aggregates would be transported by rail from Saugeen. The reason for this is the increase in handling and transportation costs resulting from lower volumes.

In summary, the shortlisted alternatives were: rail and truck transportation, without and with underground mining.

8.3.5 Transportation to the Windsor Area

Exhibit 8-12 shows the comparison of transportation alternatives for the Windsor area.

Water transportation would obviously be the most advantageous. Indeed, this is one of the transportation options presently used. Instead of the present sources in Michigan, stone could be supplied from Manitoulin Island at approximately the same delivered price as from the current sources.

Rail transportation of sand and gravel from the Saugeen area would be substantially more costly than ship transportation of stone. Because of the relatively low volumes the large terminals that are suitable for the Toronto area would not be economical. The distance of Windsor from the Saugeen area is also substantially greater than that of Toronto or London.

EXHIBIT 8–10
DELIVERED PRICES, TRANSPORTATION BY RAIL AND TRUCK, SAUGEEN–LONDON

(6 million tonnes/year)

	CN RAIL					DIRECT TRUCK
	SMALL LOADING AND RECEIVING TERMINALS					
	CENTRAL RECEIVING TERMINAL	SHORT DISTRIBUTION DISTANCE		ON-SITE USE[5] DIRECT		
		TWO SHIFTS	ONE SHIFT	TWO SHIFTS	ONE SHIFT	
Distance (km)	135	148	148	148	148	145
Annual Volume (million tonnes)	6.0	3.2	1.6	3.2	1.6	Any
Aggregate Price ($)						
In Stockpile	2.30	2.30	2.30	2.30	2.30	2.30
Loading	.30[2]	.30	.50	.30	.50	.25
Rail Rate	2.70	3.30	3.45	3.15	3.30	
Receiving Terminal(s)	1.15	1.15	1.60	.90	1.35	
Truck to Customer	1.15[1]	.90[4]	.90[4]	—	—	6.85
	7.60	7.95	8.75	6.65	7.45	9.40

Average Price from Local Supplier:	
FOB Plant	2.55
Truck to Customer	1.35[3]
	3.90

[1] 15 km
[2] Two plants, 3 million tonnes each
[3] 20 km
[4] 10 km
[5] Large customers, such as concrete plants.

EXHIBIT 8–11
DELIVERED PRICES, RAIL TRANSPORTATION COMBINED WITH UNDERGROUND MINING, SAUGEEN–LONDON

(4 million tonnes/year from the Saugeen area)
(2 million tonnes/year underground mining)

	RAIL		LOCAL UNDERGROUND MINING
	CENTRAL RECEIVING TERMINAL	THREE SMALL RECEIVING TERMINALS[4]	
Distance (km)	135	135	15
Annual volume (million tonnes)	4.0	4.0	2.0
Aggregate Price ($)			
In Stockpile	2.30	2.30	4.65
Loading	.35[2]	.35[2]	.25
Rail Rate	2.90	3.40	
Receiving Terminal(s)	1.50	1.25	
Truck to Customer	1.15[1]	.90[3]	1.15[1]
	8.20	8.20	6.05
Average		7.48	

[1] 15 km
[2] Two plants, 2 million tonnes each
[3] 10 km
[4] Two 1.6 million tonnes and one 0.8 million tonnes

Because of the high cost of rail transportation from the Saugeen area, that alternative is not considered practical. As long as fine aggregates can be trucked from Michigan at a lower price, that should be regarded as the favourite alternative for the supply of fine aggregates from an economic standpoint.

Local underground mining would be an attractive alternative for the supply of stone. Exhibit 8-12 shows that the price that could be achieved by local underground mining would be lower than the price of aggregates shipped by water.

In summary, the shortlisted alternatives for supplying coarse aggregates were: water transportation from Manitoulin Island and underground mining.

The favoured alternative for supplying fine aggre-

EXHIBIT 8–12
DELIVERED PRICES, TO WINDSOR

	STONE BY SHIP FROM MANITOULIN	SAND/GRAVEL BY RAIL FROM SAUGEEN		LOCAL UNDERGROUND MINING
Distance (km)	402	345	345	15
Annual Tonnage (million tonnes)	2.0	3.2	1.5	2.0
Aggregate Price ($)				
In Stockpile	2.35[1]	2.30	2.30	4.65
Loading	.85	.30	.50	.25
Ship Rate	2.50	—	—	
Rail Rate	—	5.35	5.50	
Receiving Terminal	.80[3]	1.15[4]	1.15[5]	
Truck to Customer	1.15[2]	1.15[2]	1.15[2]	1.15
	7.65[6]	10.25	10.60	6.05

(1) Assumes quarry adjacent to marine terminal
(2) 15 km
(3) Assumes existing terminals (estimated cost)
(4) Two receiving terminals, 1.6 million tonnes each
(5) One receiving terminal
(6) Approximately equals present average delivered price of U.S. stone

EXHIBIT 8–13
DELIVERED PRICES, TO SARNIA

	STONE BY SHIP FROM MANITOULIN	SAND/GRAVEL BY RAIL FROM SAUGEEN		LOCAL UNDERGROUND MINING	DIRECT TRUCK FROM SAUGEEN
Distance (km)	303	265	265	15	300
Annual Tonnage (million tonnes)	1.3	1.6	0.8	1.3	Any
Aggregate Price ($)					
In Stockpile	2.35[1]	2.30	2.30	4.80	2.30
Loading	.85	.50	.50	.25	.25
Ship Rate	2.05	—	—		
Rail Rate	—	5.00	5.00		
Receiving Terminal	.80[3]	1.15[5]	1.55[5]		
Truck to Customer	1.15[2]	1.15[2]	1.15[2]	1.15	8.75
	7.20[4]	10.50	10.50	6.20	11.30

(1) Assumes quarry adjacent to marine terminal
(2) 15 km
(3) Assumes existing terminals (estimated cost)
(4) Approximately equals present average delivered price of U.S. stone
(5) One receiving terminal

gates would be import by truck from Michigan. Rail transportation of fine aggregates from the Saugeen area could only be considered a contingency option, should imports from the U.S. be interrupted for some reason.

8.3.6 Transportation to the Sarnia Area

The conclusions regarding the Sarnia area were similar to those regarding the Windsor area. The costs are shown in Exhibit 8-13.

The most economical of the alternatives considered would be transportation of stone by water from Manitoulin Island. This would be possible at a delivered price approximately equal to the average price paid by Sarnia area customers for crushed stone imported from present sources in Michigan.

The delivered price of aggregates transported by rail from the Saugeen area to Sarnia would be similar to that of aggregate transported to Windsor. Although the distance would be shorter, the volumes would be smaller, resulting in similar costs. These costs would be substantially higher than the costs of supplying stone by water.

Fine aggregates to accompany the stone shipped by water will likely be available from Michigan sources and can be transported by truck at much lower delivered prices than if they were transported by rail from Saugeen. Thus, the rail transportation alternative from Saugeen to Sarnia would not be attractive as long as fine aggregate sources from the United States are available.

As in the Windsor area, local stone can be produced from underground mines at lower prices than the price of equivalent material shipped by water.

Direct trucking of aggregates from the Saugeen to the Windsor area was costed for the sake of comparison. The cost would be so high, however, that this alternative was eliminated from further consideration.

In summary, the shortlisted alternatives for supplying coarse aggregates were: water transportation from Manitoulin Island and underground mining.

The favoured alternative for supplying fine aggregates would be import by truck from Michigan. Rail transportation of fine aggregates from the Saugeen area could only be considered a contingency option, should imports from the U.S. be interrupted for some reason.

CHAPTER 9
Comparison of Supply Systems

In Chapter 8 alternative long distance transportation systems were compared with each other and with the option of continuing local supply, from an economic point of view.

The comparisons indicated that certain options would be too costly and would not offer any significant non-economic advantages over the less costly systems. These options were therefore eliminated from further considerations.

The remaining systems were then assessed and compared, considering their costs, the impacts the systems would have on people and on the environment, how well the customers would be served, and how much petroleum fuel would be consumed.

These broad criteria were analyzed under eight specific factors, defined below:

(i) *Delivered price* — the average price of the product delivered to the customer.

(ii) *Capital investment* — the total additional amount of capital required to implement the system, over and above the capital requirements of the system for which these requirements are the lowest.

(iii) *Community impacts* — the disruptive impacts on people, affected either by dislocation or by such environmental effects as noise, vibration, fumes, dust, perceived safety hazards, property damage and traffic delays.

(iv) *Impacts on agricultural land* — the amount of land removed from agricultural production.

(v) *Impacts on the natural environment* — the impact on natural ecosystems and landscapes.

(vi) *Flexibility* — the ability of a system to respond with minimum delay to changes initiated by a customer.

(vii) *Reliability* — the degree to which a customer is assured of receiving the required product on time.

(viii) *Petroleum fuel consumption* — the total additional amount of petroleum fuels required by the operation of the system, over and above the petroleum fuel requirements of the system for which these requirements are the lowest.

9.1 SUPPLY SYSTEMS FOR THE TORONTO AREA

Four systems were assessed and compared in detail:

1. Continuing local supply from surface extraction.
2. Rail transportation on a double-track line from the Saugeen area.
3. Truck transportation from the Saugeen area.
4. Local supply from underground mining.

The comparison of systems was carried out for an annual production level of 40 million tonnes, approximately 20% higher than today's production. This is forecast to be the approximate demand for mineral aggregates in the Toronto area by the time a long distance transportation system could be implemented.

In practical terms, the volume of mineral aggregates transported to the Toronto area from remote sources may reach that level only gradually over a period of time, as existing local sources become successively depleted. However, if the evaluation of alternative systems resulted in the finding that, all considered, long distance transportation of mineral aggregates to the Toronto area was the most desirable option, the ultimate objective would then be to supply all of the area requirements from remote sources rather than from local production sites. The evaluation of alternative systems must therefore be carried out for volumes that are in the same order of magnitude as the total area demand.

9.1.1 Continuing Local Supply from Surface Extraction

(i) Delivered Price

The average delivered price of aggregates in 1979 was about $4.55 per tonne in the Toronto area. Disregarding the effects of general inflation this price would prevail with only modest increase in the future if the present system of supply continued. Whereas the sources of supply would gradually move further from the centre of the area, new points of consumption would also move in the same directions, hence average delivery distances would increase only slightly.

(ii) Capital Investment

Continuing local supply from surface extraction requires the least capital investment among the evaluated systems. This option was therefore chosen as the "basic" system and the additional capital requirements of all the other alternatives were compared with those of this system.

In the "basic" system the capital requirements would consist of:

- the investment in new production facilities, as old sites become depleted and the demand for mineral aggregates continues to grow,

- renewal of depreciated plant and equipment, including production machinery, distribution trucks and other facilities.

The additional capital requirements shown in the evaluations for the other evaluated systems are the amounts required in excess of the "basic" investments described above.

(iii) Community Impacts

The community impacts of continuing local supply from surface extraction would be similar to those of today but the total number of people affected would increase in proportion to the gradual increase in aggregate production and the spreading of production into surrounding areas.

Two groups of people would be affected:

- people in the vicinity of existing and new extraction sites, and
- people along the transportation routes.

The population densities in the vicinity of existing and potential future extraction sites in the Toronto area average 0.3 persons per hectare. To satisfy the demand of 40 million tonnes of aggregates approximately 400 hectares (1000 acres) of new land would have to be opened to production each year. This area would be made up of numerous sources throughout the area and would usually be acquired by the aggregate producers on the free market. At a rate of 400 hectares per year for aggregate extraction and buffering, on average about 120 persons would thus relocate each year.

Ongoing local supply would continue the existing negative impacts of aggregate truck traffic, such as noise, vibration, fumes, dust, traffic delays, property damage and perceived safety hazards. Without special measures to mitigate the harmful effects of this traffic, the communities presently experiencing heavy aggregate truck traffic would continue to be affected.

Although some measures, such as the obligatory use of tarpaulins for controlling dust, were introduced by the Ontario Government, the other detrimental effects on residents along the transportation routes would still prevail.

Whereas the Ontario Government has developed strict policies regarding the protection of the land and the environment through the rehabilitation of production sites, these measures could be much more effective if further policies were adopted to reduce the harmful effects of trucking. Examples of measures for the implementation of such policies are presented in Section 9.16 of this chapter.

(iv) Impacts on Agricultural Land

With respect to impacts on agricultural land, continuing local supply from surface extraction would require the removal of approximately 300 hectares (750 acres) of land from agricultural use every year (assuming that 25% of the land requirements are buffer zones suitable for agricultural use). However under Provincial policies, approximately the same amount of land would have to be rehabilitated each year and *returned* to agricultural or other uses.

If the land was returned to agricultural use there would be no long term loss in the quantity of agricultural land, although the rehabilitation may require special efforts. If the land was returned to other uses the change would have probably occurred anyway under the pressure of competition for the use of land. It can therefore be concluded that adherence to Provincial rehabilitation policies minimizes the long term detrimental agricultural impacts of aggregate production.

(v) Impacts on the Natural Environment

Present licensing policies are in force to protect the natural environment by preventing the opening of pits and quarries near environmentally sensitive features. However, ongoing local supply in the Toronto area could still affect the natural environment to some degree at certain locations during the years of surface extraction. Rehabilitation after the completion of production, as required by government policies and regulations, would minimize the long term effects.

(vi) Flexibility

The flexibility of the local supply system is high, with little potential for further improvements. The proximity of the sources to the points of use ensures the opportunity for "last minute" changes in aggregate orders.

(vii) Reliability

The reliability of the local supply system is also high, with little potential for further improvements. Competition among the large numbers of producers in the area ensures the availability of alternative sources of supply in case one source failed.

(viii) Petroleum Fuel Consumption

The total annual amount of petroleum fuels consumed in a system of continued local supply, providing 40 million tonnes of aggregates, was estimated to be 60 million litres.

This consumption consists of:

- the fuel consumed by distribution trucks, and
- petroleum fuels consumed at the production sites.

9.1.2 Rail Transportation from the Saugeen Area — Double-Track Line

(i) Delivered Price

The delivered price of aggregates transported by rail on a double-track line from the Saugeen to the Toronto area would at best be approximately $7.00 per tonne in 1979 dollars. This would be $2.45 higher than the average delivered price in a system of continuing local supply: an increase of 54 percent.

A total annual consumption of 40 million tonnes of aggregates would thus cost the consumers at least an

additional 98 million dollars per year if the aggregate was transported by rail from the Saugeen area instead of being supplied from local pits and quarries.

These cost estimates were based on the minimum rail rate that could be charged by the railways. If their rates were to be higher, the extra costs of the long distance transportation option could also be significantly higher than those used in this evaluation.

(ii) Capital Investment

The additional capital investment required for a long distance rail transportation system suitable for supplying 40 million tonnes of aggregate per year was estimated to be $410 million, over and above the investment required for the "basic" system of continuing local supply.

The additional investment would consist of the upgrading of the rail line, the construction of new sections, grade separations, new locomotives, rail cars, rail loading and receiving terminals and differences in capital costs related to production facilities.

(iii) Community Impacts

The community impacts of the long distance rail transportation options on people in the *source area* would be significantly different from the option of continuing local supply, for the following reasons:

- The population density in the Saugeen area is much smaller than in the Toronto area: approximately 0.1 persons per hectare as opposed to an average of 0.3 persons in those parts of the Toronto area where aggregate would be extracted. Extraction of 40 million tonnes of aggregates per year would require approximately 400 hectares (1000 acres) of new land each year. In the Saugeen area this would mean the relocation of approximately 40 persons per year, on average, compared with 120 persons in the Toronto area at the same level of production.
- Trucking near the production sites would disturb fewer people since the entire extraction system would be designed in such a way that trucking from the extraction sites to the processing plants would occur on private roadways, far from residential properties.

The entire area required to be designated for aggregate extraction would be approximately 8000 hectares (20,000 acres). Such an area would secure a supply of aggregates for 20 years at a rate of 40 million tonnes per year. Extraction would begin in one part of the area with the initial relocation of some people. Extraction would then gradually move on to other sites while the depleted sites would be rehabilitated and returned sequentially for appropriate uses. Subsequently, people would begin to move into the area again while others would be moving out from other locations as extraction moved slowly onward within the designated area.

The achievement of minimum disturbance would thus require a highly organized and well designed system. It is unlikely that such a system could be implemented without expropriation, affecting the entire 8000 hectares (20,000 acres) required.

The number of people who would have to relocate in the Saugeen area would be about one quarter of the number of people who would relocate in the Toronto area if aggregate extraction continued there. However, the impacts of relocation on the individuals would likely be more severe in the Saugeen area for the following reasons:

- Most of the people would be concentrated in basically one community; in contrast, in the Toronto area relocation would be scattered throughout a very large region and could occur as part of the normal turnover of land ownership.
- In order to design a production system in the Saugeen area that would minimize the disturbance to local residents, large land areas would have to be assembled. It is likely that such areas would have to be expropriated; in contrast, in the Toronto area, the necessary land would continue to be acquired by the aggregate producers on the free market from willing sellers.

Although fewer people would be affected in the source area by long distance rail transportation than by the option of continuing local supply, the rail transportation option would affect a significant number of people *along the transportation route.*

Even though the double-track rail line would avoid built-up areas, it would still pass through some small communities. Where towns are by-passed by new line sections, these would affect properties and cause some dislocation of people.

The train movements would affect the people who live close enough to the rail line to perceive the noise and feel the vibrations caused by the trains. They would experience 48 trains per day (in both directions combined). In comparison, the present traffic on the C.P. route between Saugeen and Brampton consists of only a few trains per week and even those few are much shorter and lighter than aggregate trains.

Grade separations would alleviate the traffic problems created by the 48 trains per day on main roads, but traffic delays and safety hazards on secondary and smaller roads would still prevail.

The rail receiving terminals in the Toronto area would be located near the freeway network with good access to the freeways so as to minimize the effects of local trucking on the arterial roads.

The major cause of disturbance in the present aggregate distribution system is the concentration of aggregate distribution trucks in the vicinity of the production plants and distribution yards. Locating the distribution yards adjacent to a freeway would minimize these impacts.

It should be noted that the effects of trucking near

the customers' sites would be the same in any of the alternatives examined. Access to the customers is determined by the location of the customers and cannot be altered by any system; this type of disturbance is therefore unavoidable.

It can be concluded that, all considered, *the reduction of the harmful effects of local trucking between the supply sites and the freeway system would be the only significant net benefit derived from long distance rail transportation with regard to community impacts.* Although the number of people disturbed near the production sites in the Saugeen area would be smaller than the number of people who would be affected near corresponding production sites in the Toronto area, the new railway line and heavy rail traffic associated with the long distance transportation option would affect additional people along the 125-kilometre transportation route. The number of people affected by this route, plus those affected in the Saugeen area, could easily approach the number of people who would be affected in the Toronto area in the case of continuing local supply.

(iv) Impacts on Agricultural Land

The impacts of extracting aggregates on agricultural land in the Saugeen area would probably not be less than the impacts of extracting aggregates in the Toronto area. In both instances, similar areas of land would have to be temporarily withdrawn from agricultural production and returned to agricultural or other uses after the extraction of aggregates and suitable rehabilitation. Rehabilitation in the Saugeen area is likely to be technically more complex and more costly because of the thin layer of top soil and would have to be achieved through careful site-specific design.

However, the new sections of the rail line would require the permanent removal of about 140 hectares (350 acres) of agricultural land. A more important consideration is the potential for a significant severance of farms, which would affect their productivity.

Thus, all considered, the long distance rail transportation option would have slightly worse agricultural impacts than the option of continuing local supply.

(v) Impacts on the Natural Environment

The natural environment would be affected by aggregate extraction to similar degrees, no matter where it occurred. As long as the protective measures applied by licensing policies are similar, there would be no significant difference between the total effects of extraction in either the Toronto or the Saugeen area.

The impact of the rail line on the natural environment would be relatively small as long as the line is properly designed.

(vi) Flexibility

The flexibility provided by the long distance rail transportation option would be somewhat greater than that provided by local supply because of the closer proximity of distribution terminals to the majority of customers in the Toronto area. The advantage would, however, be minor.

(vii) Reliability

The reliability provided by the long distance transportation option would be poorer than that provided by local supply. The reason for this would be the relatively small number of supply points in the Saugeen area as opposed to a greater diversity of suppliers in the Toronto area.

(viii) Petroleum Fuel Consumption

The long distance rail transportation system would consume a total of 110 million litres of petroleum fuels annually. This would be 50 million litres more than the amount of fuel consumed by a system of continuing local supply: an increase of 75 percent.

Conclusions

Exhibit 9-1 summarizes the conclusions drawn from the evaluation of alternative supply systems.

The long distance rail transportation option was found to be inferior to the option of continuing local supply by all of the evaluation criteria except community impacts and flexibility of service. Among these, the former is the more significant. The main reason for the advantage of the long distance transportation system with respect to community impacts would be the significant reduction in the harmful effects of local trucking if the distribution terminals were located adjacent to freeways.

It can be concluded, therefore, that if the effects of local trucking could be reduced by other means, most of the advantages of the long distance rail transportation option would disappear and only the disadvantages would remain, represented primarily by higher costs, higher capital investments and higher fuel consumption.

9.1.3 Truck Transportation from the Saugeen Area

Transportation of aggregates from the Saugeen to the Toronto area by truck was found to be the most costly of the options evaluated. The results of the full evaluation are summarized in Exhibit 9-1.

(i) Delivered Price

The delivered price of aggregates transported by truck from the Saugeen to the Toronto area would be about $9.95 per tonne, in terms of 1979 dollars: more than twice as much as the average delivered price in the option of continuing local supply.

(ii) Capital Investment

The additional capital investment for a long distance road transportation system suitable for supplying 40 million tonnes of aggregate per year was estimated to be $325 million over and above the investment required for the "basic" system of continuing local sup-

ply. This additional investment includes the cost of a dedicated freeway from the Saugeen to the Toronto area, and the investment in long distance trucks.

(iii) Community Impacts

The impact of long distance truck transportation on communities would be much the same as the impact of long distance rail transportation.

In the source areas, the local road system would be designed in the same manner as in the case of rail transportation. While in the rail transportation option, the local roads would lead to large rail loading terminals, in the trucking option these terminals would be replaced by entrances to a freeway, dedicated to aggregate traffic.

The impacts resulting from the construction and operation of the dedicated freeway would be much the same as the impacts resulting from the construction and operation of a double-track rail line, approximately along the same right-of-way.

The impacts of local distribution in the Toronto area would also be similar to those in the rail transportation alternative. Like the rail links, which would terminate at distribution yards adjacent to the Toronto freeway system and keep heavy distribution truck traffic away from arterial roads, a dedicated Saugeen-Toronto aggregate freeway would also connect directly to the Toronto freeway system and enable trucks to avoid the arterial roads.

(iv) Impacts on Agricultural Land

Similar to the rail transportation option.

(v) Impacts on the Natural Environment

Similar to the rail transportation option.

(vi) Flexibility

The flexibility of service would be significantly worse in the truck transportation option than in any of the other options, since trucks would leave the supply sites several hours before the delivery time. Thus, "last minute" changes in aggregate orders could not be made.

(vii) Reliability

The long distance trucking option would offer a higher reliability of service than the rail option, due to a great diversity of suppliers and carriers.

(viii) Petroleum Fuel Consumption

The long distance truck transportation system would consume a total of 240 million litres of petroleum fuel annually: more than twice as much as the long distance rail transportation option and almost four times as much as a system of continuing local supply.

Conclusions

In summary, the long distance truck transportation option was found to be more costly than the long distance rail transportation option. Although the required investment in a system of long distance trucking would be lower than the investment in long distance rail transportation, the operating costs of the trucking system would be much higher.

The petroleum fuel consumption of the truck transportation system would also be much higher than the consumption of the rail system.

The only advantage of long distance truck transportation over rail transportation would be the higher reliability of service, since trucking provides a large diversity of suppliers and carriers, while in a rail system, customers would have to rely on a small number of centralized supply plants and only two railways, using a single line. This relatively small advantage must be weighed against the disadvantages of high costs and high fuel consumption.

It can be concluded that, all considered, rail transportation is a more advantageous long distance transportation option for aggregates than trucking.

9.1.4 Local Supply from Underground Mining

Underground mining of stone was found to be an attractive alternative to the surface extraction of aggregates for the following reasons:

- Underground aggregate extraction does not require the relocation of people because the headframes, processing plants and terminals would occupy relatively little industrial land and extraction would occur underground where nobody would be disturbed.
- The plants could be located adjacent to the Toronto freeway system so that most of the disturbing effects of trucking between the production sites and the freeways would be eliminated.
- Impacts on agricultural land and on the natural environment would be minimized by underground extraction since the production plants would be in industrial areas.

Unfortunately, underground mining could only be a *partial solution* to the aggregate supply problem for the following reasons:

- Only stone can be mined underground. It would not be practical to produce only stone because there is a significant need for fine aggregates. These could not be manufactured from stone in sufficient quantities, at the required quality, and at a cost that could compete with the long distance transportation options. For these reasons local underground mining could not supply more than approximately 25 percent of the aggregate requirements in the Toronto area.
- Mineral rights would have to be obtained for underground extraction. It would probably not be possible to obtain such rights for land areas that have many owners. The locations suitable for underground mining of stone must therefore comply with the following requirements:

- they must be large contiguous properties of about 400 hectares,
- they must be close to the freeway network.

- The availability of such land in the Toronto area is very limited.

It was estimated that if local underground mining was combined with the long distance rail transportation option, 9 million tonnes of aggregate could be mined locally leaving 31 million tonnes to be transported by rail from the Saugeen area.

The delivered price of stone obtained from underground mining would be about $5.95 per tonne: higher than the average price of aggregate obtained from surface extraction ($4.55) but less than the price of aggregates transported by rail from the Saugeen area ($7.00).

Underground mining would have significant environmental advantages over any other system with respect to impacts on communities, on agricultural land and on the natural environment.

With respect to the flexibility and reliability of service there would be little difference between local underground mining and the long distance rail transportation option.

Conclusions

Underground mining is an alternative option to supplement surface extraction but can only supply a part of the total aggregate requirements. In the Toronto area, this part may be relatively small.

9.1.5 Continuation of the Present System or Long Distance Transportation: Is There a Third Alternative?

It has been noted that Provincial policies related to the *rehabilitation* of aggregate production sites mitigate the effects of extraction on agricultural land and on the natural environment. However, *local trucking* of aggregates still remains a serious problem in terms of community impacts.

Although some measures, such as the use of tarpaulins, have been introduced, the effects of truck noise, dust, fumes, traffic congestion and perceived safety hazards have not been reduced materially, and several communities in the Toronto area are still exposed to these effects.

To mitigate them, alternative methods of supply were investigated. It was found that:

- Long distance transportation can reduce the harmful effect of local trucking if the transportation system was properly planned and designed.
- Transportation by rail on a double-track line was the most advantageous of the long distance transportation options.
- Local underground mining of stone could not reduce the volume of aggregates that would have to be transported from long distances by more than 25 percent.
- Even the most efficient long distance transportation system would *cost the Toronto consumers approximately 100 million dollars annually* at 1979 price levels over and above today's expenditures on mineral aggregates.

The question must be asked whether the harmful effects of aggregate transportation on local residents could not be reduced by other means than long distance transportation, with the same results but at substantially lower costs? An option that could achieve the same results at lower costs may be *the improvement of the local road systems*.

Such measures may include.:

- Constructing new access roads that link the sites of aggregate extraction with major roads.
- Giving greater recognition in the Ministry of Transportation and Communications' municipal roads subsidy program for improving municipal roads used for aggregate haulage.
- Designating certain routes for aggregate hauling.
- Enlarging the road surfacing program so that all roads used for significant aggregate haulage would be hard surfaced.
- Recognizing the special requirements for aggregate traffic in road improvement programs, such as truck-climbing lanes, improvements of intersections, and other measures which will improve the flow of traffic on these roads, and minimize the interference caused by an excess of aggregate trucks.
- Considering new legislation to provide for additional control over the movement of aggregate vehicles which will minimize the aggravation to adjacent residents and other motorists.

Such measures could achieve reductions in the environmental impacts of aggregate trucking that would be equal to those attainable through long distance transportation, but probably at much lower costs than the additional 100 million dollars that would have to be spent by the consumers on aggregates in the Toronto area every year if they were transported by rail from the Saugeen area, and more if they were transported from still farther away.

Since the Provincial and municipal governments are significant consumers of aggregates, they themselves would save much of the money to be spent on road inprovements if the alternative of long distance transportation could thus be avoided.

9.2 SUPPLY SYSTEMS FOR THE LONDON AREA

The options for supplying mineral aggregates to the London area were evaluated at a level of 6 million tonnes per year.

The options were:

- Continuing local supply from surface extraction.
- Rail transportation on existing rail lines from the Saugeen area.
- Truck transportation from the Saugeen area on existing highways.
- Local supply from underground mining.

The differences between these options and those evaluated for Toronto are in the use of transportation routes. The relatively small volume of aggregate traffic would not warrant the relocation of railway lines or the construction of a dedicated freeway.

Many of the conclusions reached for the London area are similar to those reached for the Toronto area. It would be repetitious to describe them in detail and only the differences between the Toronto and London areas are highlighted below.

The *delivered price* of aggregates under the rail transportation option, which is the least costly of the long distance alternatives, would be about $7.60 per tonne at 1979 price levels; this would be almost twice as high as the average actual 1979 price of $3.90. Under the long distance trucking option, the delivered price would be $9.40.

The *community impacts* of aggregate extraction in the Saugeen area would be similar to the impacts of the system that would supply Toronto. The supply of London would add approximately 15 percent to the extraction area required for the supply of Toronto.

The community impacts of the transportation routes to London would be worse than the impacts of the routes to Toronto. Since the volume of traffic would not justify the construction of new rights-of-way for a rail line, the existing CN lines would have to be used.

Approximately two-thirds of the 135 km distance between the Saugeen and London areas consist of low-traffic branch lines that presently experience only a few short light trains per week. Aggregate transportation would add 7 long heavy trains per day (in both directions combined) to the present light traffic. The community impacts of these trains would be significant.

The location of the rail receiving terminal or terminals would present problems. London does not have a freeway network similar to that of the Toronto area. Thus, the concentration of distribution trucks in the vicinity of a relatively large rail receiving terminal would have worse effects than the present truck concentration in the vicinity of the existing production sites.

Since it was found in the evaluations for the Toronto area that the only significant advantage of long distance rail transportation would be the reduction of the harmful effects of local hauling, the lack of opportunity for such reductions in the London area appears to eliminate all the advantages of long distance rail transportation.

In the trucking option, the volumes would not justify the construction of a dedicated freeway and, therefore, trucks would use the existing road network. The traffic could be divided between two routes. On each of these the combined two-way truck volume would exceed 1,000 trucks on a peak day or 100 trucks in the peak hour. This means that approximately one aggregate truck would pass each direction every minute through the communities along the roads over a distance of approximately 140 kilometres. The effects of these trucks would certainly be worse than the effects of truck movements under the option of continuing local supply, considering the much shorter travelling distances of that option.

Conclusion

It can be concluded that long distance transportation of aggregates by either rail or truck, would offer no advantage over continuing local supply for the London area.

Underground mining of up to one third of the aggregate requirements of the London area would be an attractive option for supplementing surface extraction, offering advantages similar to those found for the Toronto area.

9.3 SUPPLY SYSTEMS FOR THE WINDSOR AND SARNIA AREAS

The most favoured future system of aggregate supply for the Windsor and Sarnia areas would be the continuation of the present system with a change of supply of crushed stone from the United States to sources on Manitoulin Island.

It was found that the delivered price of aggregates would not change as the result of changing the supply source: the average delivered price of stone in terms of 1979 dollars would remain in the range of $7.20 to $7.65 per tonne.

The environmental impact of quarrying stone on Manitoulin Island would be minimal since the quarries would be close to the ship loading docks and could be designed in a way that would have minimal environmental impacts. The land for the quarries could be acquired in a normal commercial manner.

Existing docks in Windsor and Sarnia could handle the crushed stone delivered by ships and it would be distributed in the same manner as today. The distribution of 2 million tonnes of stone from several docks in Windsor and of 1.3 million tonnes of stone in Sarnia would not cause significant trucking problems provided that the docks are appropriately located.

It was estimated that the peak truck traffic to distribute 1 million tonnes of aggregates per year would consist of approximately 20 loaded movements per hour. Such volumes represent a small fraction of other traffic.

However, it was found that in Sarnia the present location of the aggregate docks and the associated traffic are considered a nuisance and a hindrance to the redevelopment of the waterfront — a project that is actively proceeding.

It is interesting to note that the cost of stone mined from underground sources could be significantly less than the present cost of stone shipped by water.

Fine aggregates required to supplement the crushed stone would continue to be trucked within or into the Windsor and Sarnia areas from existing Canadian sources over short distances as long as the supplies last. As supplies of sand near Windsor and Sarnia will be gradually depleted the volume of sand imported from the United States is expected to increase. The trucks required to carry these amounts would not represent a significant fraction of the total traffic on the affected routes.

Fine aggregates from remote Canadian sources would not be competitive with imported sand and could only be looked upon as an emergency option should the supplies from the United States be disrupted for some reason. In that case fine aggregates would have to be transported by rail from Saugeen or other sources at delivered prices that would exceed $10.00 at 1979 price levels. The volumes would be relatively small and no special rail facilities would be justified beyond conventional loading and unloading terminals.

The additional traffic of at most 2 trains per day (in both directions combined) to Windsor and 1 train per day to Sarnia would not have significant environmental effects when considered in conjunction with other existing traffic.

EXHIBIT 9–1
COMPARISON OF OPTIONS

		CONTINUING LOCAL SUPPLY FROM SURFACE EXTRACTION	LONG DISTANCE TRANSPORTATION	
		(1)	RAIL (2)	TRUCK (3)
(i)	Delivered Price – $/tonne	4.55	7.00	9.95
(ii)	Additional Investment – million $	—	410	325
(iii)	Community Impacts – Sources	Relocate 120 persons/yr. (free market)	Relocate 30 persons/yr. (expropriate)	
	– Line haul	—	Impacts along 125 km route	
	– Distribution	Disruptive	Better than (1)	
(iv)	Impacts on Agricultural Land	Rehabilitation reduces impact	Source area: same as (1) Route: added impact	
(v)	Impacts on Natural Environment	Impacts during years of production	Same as (1)	
(vi)	Flexibility	Good	Somewhat better than (1)	Worse than (1)
(vii)	Reliability	Good	Worse than (1)	Same as (1)
(viii)	Petroleum Fuels – million litres/yr.	60	110	240

CHAPTER 10
Issues of Implementation

It has been shown in the study that the supply of mineral aggregates in the Toronto, London, Windsor and Sarnia areas depends on the policies of the Provincial and the local governments with respect to controlling extraction. The most restrictive position considered in this study has been one that would allow the granting of very few new licences, but all the existing licences would be allowed to continue until the licensed reserves are depleted.

It was found that in a moderately growing economy such policy would have the following results:

- In the Toronto area mineral aggregate supplies would be depleted approximately by the year 2000.
- In the London area supplies would be depleted shortly after 1990.
- In the Windsor area coarse aggregates are theoretically available but are currently used only for chemical purposes and are not being sold commercially. Coarse and fine aggregates are presently being imported into the area, although a limited supply of locally produced sand will continue for some years yet. Stone of a quality not acceptable for all uses is being produced and will be available for a considerable time in the future.
- In the Sarnia area the supply of fine aggregates would be depleted around 1990. All coarse aggregates and some sand are already imported into the area.

10.1 SARNIA AND WINDSOR AREAS

The study has shown that the continued supply of coarse aggregates to the Sarnia and Windsor areas by water, supplemented by imports of sand by truck is a satisfactory system. It is the most economical and from an environmental point of view it is likely to be more acceptable than supplying sand and gravel from the Saugeen area or from other remote areas by rail.

Alternatives to the present system include:

- Reducing the imports of stone from the United States sources and replacing that supply by domestic products from Manitoulin Island.
- Extracting coarse aggregates through local underground mining.

These developments are economically and technically feasible and, therefore, the changes may occur as the result of activities by entrepreneurs without any government intervention.

10.2 TORONTO AND LONDON AREAS

In the Toronto and London areas the choice of feasible alternatives are different. The supply of mineral aggregates from remote sources would be substantially more costly than from existing sources. It was shown that whereas in 1979 dollars the average delivered price of mineral aggregates in the Toronto area was $4.55, even in the most economical transportation system it would not be possible to supply aggregates from the Saugeen area for less than $7.00, i.e., for a price that would be 54 percent above the price of the locally produced material.

Thus, as long as adequate supplies are licensed within or adjacent to the Toronto area, material from the Saugeen area could not compete. Similar conclusions can be reached for the London area.

The likely course of events is described below under two conditions:

- No government intervention
- Government intervention.

No Government Intervention

If the supply of mineral aggregates became scarce because of restrictions on licensing, prices would increase. This would happen in the early 1990's in the Toronto area and in the mid-1980's in the London area. Gradually more and more suppliers would run out of material and cease operations. Eventually only a relatively small number of suppliers would remain. These would probably be the larger producers, some of whom are financially strong and diversified. Reduced competition would make it possible for them to increase their prices by holding back production in a manner similar to today's experience in the oil business. As prices would start to increase under the pressure of market forces the remaining producers would find it preferable to keep the material in the ground, expecting even higher prices in the future. A classical shortage situation would develop in which prices would climb sharply, encouraged by speculation.

Under the umbrella of high prices, supplies from the Saugeen area would suddenly become competitive. There is, however, a good reason why entrepreneurs would be hesitant to make the required large capital investments in plants and terminals in that area. Knowing that the cost of production in the Toronto and London areas was substantially lower, investors would be justly concerned that as soon as they have entered the market, the local suppliers, who would still have some reserves, would drop their prices

sufficiently to make the Saugeen material uncompetitive.

This situation could prevail for years, at least until the licensed mineral aggregate reserves in the Toronto and London areas became almost depleted.

At that time another concern would be raised by potential investors in the Saugeen area. Since possible mineral aggregate resources are abundant in the Toronto and London areas and their extraction is only limited by *policies*, it could be expected that under the pressure of high prices the policies might be relaxed. Suddenly, there would be enough local material available to put the Saugeen material out of business for many more years.

It can be concluded, therefore, that without government intervention the large investments necessary for the development of a supply system from the Saugeen area or from any other remote area to Toronto and London would probably not be made. Unless new local licences were issued, mineral aggregate prices would drastically increase in the Toronto and London areas. Eventually prices would become sufficiently high for *small* production plants to become relatively safe investments throughout the Saugeen area and small quantities of aggregates would be trucked to Toronto and London. This would finally stabilize the price at the level determined by the cost of trucking.

These events would occur in a manner that would be rather disruptive to the construction industry. For a while aggregates would be in short supply, and ultimately, the price would be in the order of $10 per tonne in 1979 constant dollars: more than twice today's delivered price.

As supplies in the Toronto and London areas continued to run out, more material would be trucked from long distances in an unco-ordinated manner. This would impose substantial traffic on existing roads and create an environmentally worse situation than today's conditions, at substantially higher costs.

Eventually the government would probably build a new freeway to handle the trucks. This would reduce the effects of trucking and, around the year 2000, a costly system would evolve, similar to the long distance truck transportation alternative of this study.

As noted, the system would reach this state through a rather disruptive period during which the mineral aggregates would be in short supply in the Toronto and London areas. The construction industry would seriously suffer during this period. Furthermore, since the possibility of policy changes resulting in granting of new licences to local competition would always loom in the eyes of the would-be investors in the Saugeen area, investors would be cautious to build even small plants. Thus a precarious supply situation would exist with high prices and unsatisfactory levels of service. This would be detrimental to the construction industry which would put strong pressure on government to grant new local licences. Thus, would-be investors would be even further deterred from expanding production in the Saugeen area.

These considerations indicate that if the Provincial and local governments were to apply a restrictive *licensing policy* under which few licences were issued within or in the vicinity of the Toronto and London areas, the Provincial Government would also have to adopt a *transportation policy* for mineral aggregates that would include government participation in the development of a co-ordinated and planned transportation system.

Government Intervention

The Provincial Government could participate in several ways in the development of a transportation system:

- through subsidies
- through ownership
- through the establishment of a marketing board or a similar organization.

Government subsidy would ensure an investor who provides efficient plants, terminals and transportation facilities that he can sell the mineral aggregates in the market areas at competitive prices.

To recover the funds for the provision of subsidies the Provincial Government would likely have to levy a tax on either the production or the sale of aggregates.

As aggregates continued to be depleted in the Toronto and London areas the volumes that would have to be transported from remote sources would increase, requiring a gradual increase in subsidies and, therefore a gradual increase in the amount of taxes. This transition period would not be very desirable for government which would be forced to constantly increase the taxes: a very unpopular process.

The alternative to subsidies would be for the Provincial Government to *own* the capital-intensive facilities. If government wished to recover its capital investment, the need for taxation would be the same as in the previous case. The government would likely lease the facilities to private enterprise and assume the role of landlord rather than operator. In the end, this approach would not be much different in terms of financial or economic impact from the subsidy approach.

A third alternative would be for the Provincial Government to establish a *marketing board* or similar organization. An example of such a board is the Canadian Wheat Board. The marketing board would pay approximately the same market prices for aggregates to the producers in the various parts of the Province and sell the material at uniform local prices (with local prices being not necessarily the same in all regions). Transportation would be the responsibility of the marketing board and the transportation costs would be spread over the entire system. Thus, blended prices would automatically develop throughout the Province.

Each physical element of the system should logically still be the responsibility of private enterprise, in the same way as it is in the Canadian grain distribution system. However the entire system could not function without significant government intervention. Transpor-

tation and handling charges would be paid by the marketing board to the truckers, railways and terminal operators. The customers would make payments for the aggregates to the marketing board which, in turn, would make payments to the producers.

Prices would be determined each year so as to set the marketing board's profit to zero. In the case of surplus, additional payments would be made to the producers at the end of the year. In the case of shortfall, prices would be raised accordingly for the following year.

The alternative described above would ensure the continuing role of private enterprise within the system. Truckers engaged in distribution would compete with each other. Using adequate purchasing policies the marketing board could keep the producers competitive to some extent, since different prices would be paid for different qualities of material and levels of service. However, it is obvious that the competitive environment with only two or three multi-million tonne plants in the Saugeen area would be less advantageous to the consumers than a system with many competitors.

The major difference between the present and the described marketing system would be the elimination of price competition at the consumers' level, although competition in quality of service could still exist between alternate points of supply.

Like all marketing boards, the Aggregate Marketing Board would have to strike a reasonable balance between providing adequate income to the producers and acceptable prices to the construction industry. The mineral aggregate business, being highly competitive, might have experienced depressed prices in recent years that could be alleviated by a marketing board. However, the reduction of competition would not benefit the consumers.

The described system would undoubtedly result in significant increases in the prices of mineral aggregates in the Toronto, London, and similar areas. These increases would be economically unavoidable if mineral aggregates had to be transported over long distances, regardless of the system of implementation. The marketing board approach would appear to be the least disruptive of the alternatives examined, and indeed, the only practical one.

In summary, the implementation of a long distance transportation and supply system implies the necessity for changing the entire structure of the aggregate industry in Ontario. Such a major change would have adverse impacts on all consumers of aggregates throughout the Province through higher prices and reduced competition.

As concluded in Chapter 9 the options available for securing a continuing supply of mineral aggregates to Ontario consumers are:

- Implement a long distance transportation system. This will cause a significant increase in price, a shift in the areas affected by the extraction and transportation of aggregates, and a significant change in the entire structure of the aggregate industry, with associated negative impacts on the service provided to consumers.
- Continue the granting of new licences and accept the negative impacts in the vicinity of the production sites and along the transportation routes.
- Implement a *third option* that would significantly reduce the negative impacts of both options described above. In that third option some of the funds that would be spent on long distance transportation would be rather spent on the improvement of local conditions to minimize the harmful effects of aggregate production and, particularly, distribution. Such local improvements would include the construction of new access roads, the designation of routes for aggregate haulage, the implementation of road improvement programs that recognize the special requirements of aggregate traffic, and the consideration of new legislation to provide for additional control over the movement of aggregate trucks.

The costs and the extent of the improvements under that "third option" can only be determined by a detailed examination of the specific conditions at each critical location. It is likely, however, that the "third option" could produce improvements similar to those that would result from long distance transportation, but at a considerably lower cost and without the problems of implementation described in this chapter.

APPENDIX A
Forecasting Methodologies

A.1 FORECASTING CATEGORIES

Four different methods were applied to the forecasting of mineral aggregate consumption in four categories of use:

(1) Manufacturing of concrete[(1)]

(2) Residential building construction

(3) Road construction

(4) Non-residential building construction, non-road engineering construction and all other uses.

Since the use of aggregates for concrete was forecast separately only those aggregates were included in the forecasts for categories (2) to (4) that were used in forms other than concrete.

Construction in categories (2) and (3) was forecast by using direct methods:

- The construction of housing units was forecast by projecting the population and its age distribution in the study areas.
- Provincial and municipal road construction was forecast by working with Ministry of Transportation and Communications staff and data.
- Forecasts for subdivision roads were derived from the forecasts of housing units.

The manufacturing of concrete (Category (1)) and construction in Category (4) were forecast by relating these activities to overall economic factors, such as the Gross Provincial Product (GPP) and changes in the GPP. Econometric models were developed for that purpose.

To forecast aggregate consumption by these "indirect" methods the growth of the Provincial economy had to be projected. Two such projections were prepared.

A.2 FORECASTING STEPS

The forecasting methods are described below for each Category.

Forecasts for the consumption of aggregates used in concrete were derived in two steps: first, the production of *concrete* was forecast, followed by an estimate of the amount of aggregate used per tonne of concrete (the so-called "input factor").

Forecasts for the consumption of aggregates used for residential building construction were also derived in two steps: first, the *numbers* of *housing units* were forecast, followed by an estimate of the *amounts of aggregates used for the average housing unit* (input factor in tonnes per housing unit).

Forecasts for the consumption of aggregates used for road constructiom and for all other activities that need aggregates were also derived in two steps: first, the *funds that will be spent* in each category were forecast, followed by an estimate of the *amounts of aggregates used* per dollar expenditure (input factors in tonnes per dollar expenditure).

The description of the forecasting methods is structured according to these steps in the text below. A flowchart of the steps is presented in Exhibit A-1.

First, economic projections were prepared. These were used to forecast concrete consumption and the funds spent on aggregate consuming activities other than the manufacturing of concrete, residential building construction and road construction.

Next, forecasts were prepared for:

- the production of concrete (in tonnes)
- the construction of housing units (in numbers of housing units and acres of land)
- road construction expenditures (in dollars)
- expenditures on all other aggregate consuming activities (in dollars).

Next, the input factors were determined for each of the categories above in tonnes of aggregates used per unit of output shown in brackets for each category above.

A.3 ECONOMIC PROJECTIONS

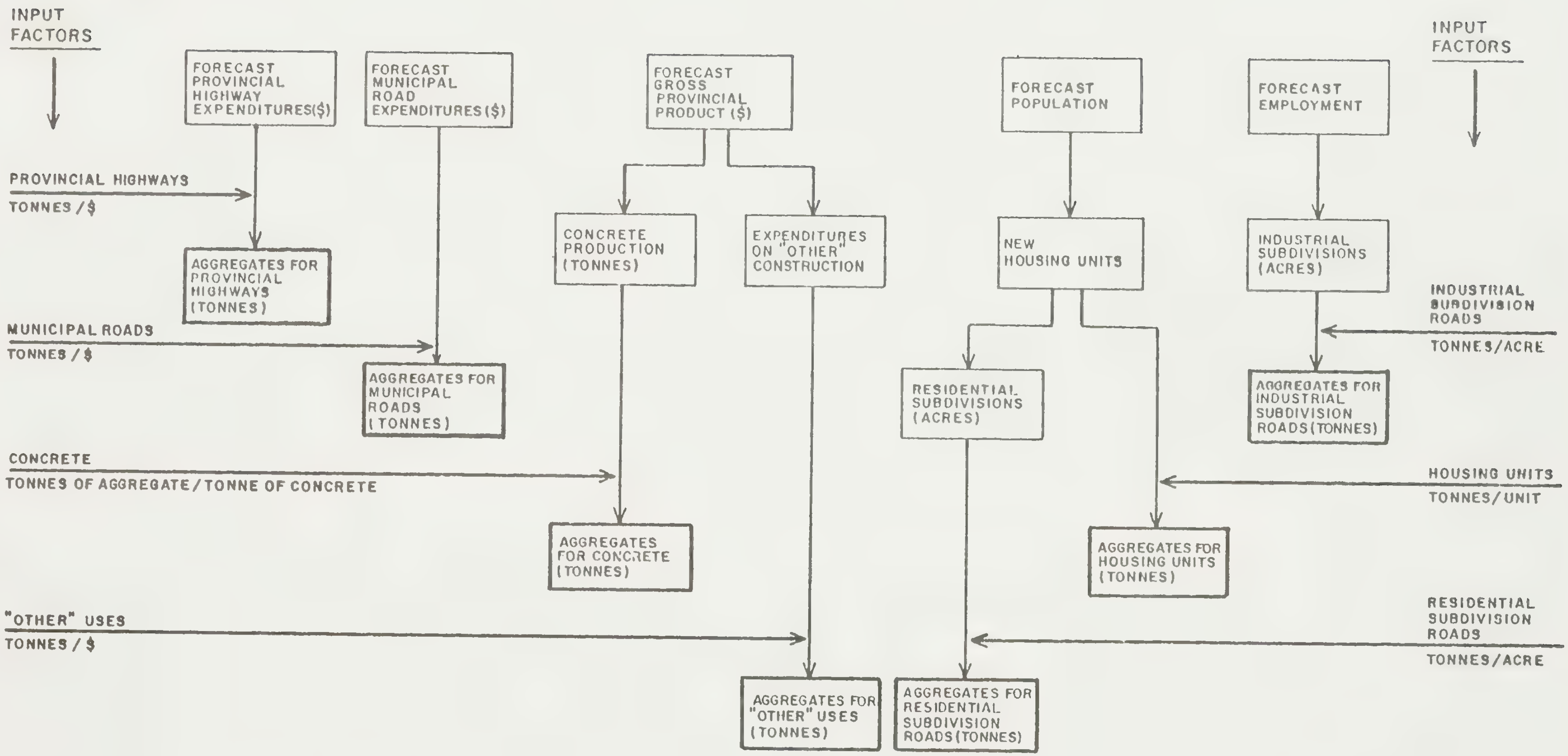
To project the growth of the Gross Provincial Product, two economic projections were used.

Projection 1 was based on an assumption of *continuing growth*, in which the Canadian Gross National Product (GNP) would continue to grow at a rate approximately equal to the average growth rate experienced in the 1974-1978 period. Accordingly, an annual real growth rate of 3.35% in the Gross National Product was assumed to continue to the year 2000. This rate, considered "most likely", corresponds to the growth projected by several sources, including projections for the 1980's contained in the Economic Council of Canada's 1979 Annual Report*.

Ontario's Gross Provincial Product (GPP) has grown at a slower pace in recent years and has been consistently lower than the growth rate of the GNP by 1.2 – 1.3 percentage points throughout the 1970's. It

(1) *Concrete refers to products containing portland cement as binder.*

* *Means of three fuel-price scenarios.*



FORECASTING METHODOLOGY

A-1

was assumed that its growth rate would gradually come closer to that of the Gross National Product, equalling it by 1991 and thereafter.

Projection II was based on *slow growth*, in which Ontario's Gross Provincial Product would grow at a slow rate of 1.75% per year in real terms throughout the rest of the century. This growth rate corresponds to the average growth on Ontario's GPP from 1973 to 1978.

A.4 FORECASTS OF CONCRETE CONSUMPTION

A forecasting model was developed for the production of concrete and concrete products in Ontario. The statistical technique of linear regression was used to fit historical data to a suitable equation.

After substantial experimentation, it was found that the production of concrete and products in metric tonnes in a particular year depends on two factors:

- the Gross Provincial Product in the year in question, expressed in millions of dollars
- the change in the Gross Provincial Product during the four years preceding the year in question (i.e., the difference between the GPP in the year in question and the GPP four years earlier).

This finding reflects the lagging nature of construction — the need to accommodate the results of previous economic growth.

The equation that expresses the production of con-

EXHIBIT A–2
HISTORICAL CONCRETE CONSUMPTION AND GROSS PROVINCIAL PRODUCT

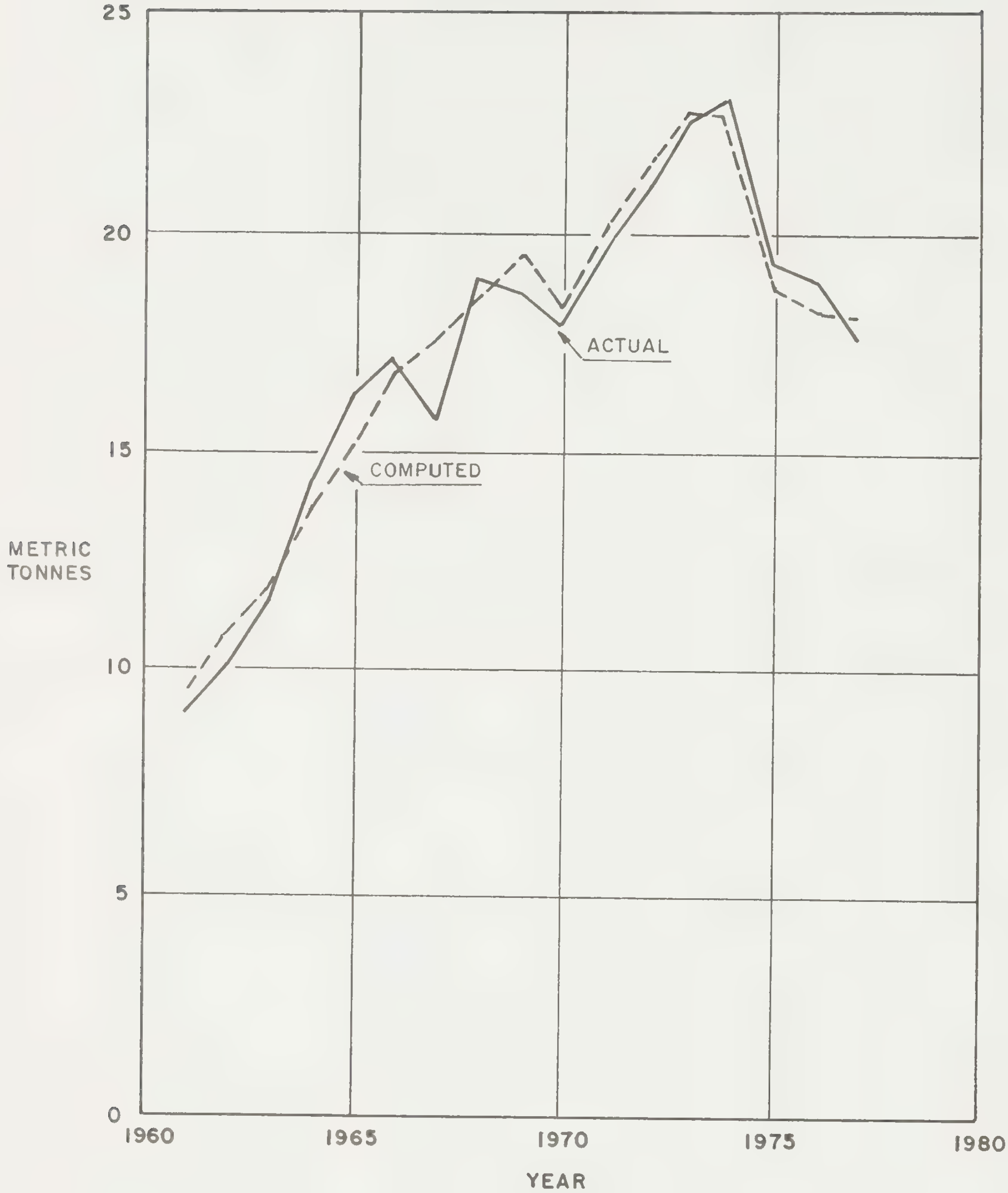
	CONCRETE CONSUMPTION		GROSS PROVINCIAL PRODUCT	
	Bulk Consumption (million tonnes)	Adjusted for Small Users and Roads[1] (million tonnes)	Current Dollars[3] (million $)	1971 Dollars[4] (million $)
1957				21,056
1958				21,004
1959				21,677
1960				22,186
1961	9.15	9.0		23,224
1962	10.11	10.2	17,838	24,302
1963	11.26	11.5	19,054	25,473
1964	13.70	14.2	20,912	27,300
1965	15.22	16.0	22,944	29,006
1966	16.21	17.0	25,696	31,109
1967	14.98	15.6	27,911	32,492
1968	17.94	18.8	30,771	34,691
1969	17.78	18.5	34,061	36,783
1970	17.12	17.9	36,282	37,404
1971	18.74	19.5	40,000	40,000
1972	19.93	20.9	44,982	42,881
1973	21.33	22.5	51,822	45,220
1974	21.75	23.0	60,705	45,609
1975	18.18	19.1	66,601	44,759
1976	17.94	18.9	76,137	46,624
1977	16.76	17.5	84,651	48,344

(1) Bulk consumption figures from column 1 are increased by 10% to account for small users, and reduced by the estimated inputs to road construction (3 tonnes per 1971 dollar) to avoid double counting.

(2) Due to various inconsistencies in the data, it was concluded that 1961 was the first reliable year for concrete consumption.

(3) First available year as calculated by Statistics Canada is 1962.

(4) For 1962–1977, current dollar values from Statistics Canada are deflated by the implicit GNP price index. For 1957–1961, constant dollar GPP's from the Ontario Economic Review were adjusted by the ratio of the estimates of the Ontario GPP for 1962 and the corresponding Ontario Economic Review figure (to make the series consistent).



CONCRETE CONSUMPTION - ONTARIO A-3

EXHIBIT A–4
POPULATION PROJECTIONS FOR EACH DEMAND AREA(1)

	BASE YEAR 1977 (estimated)	1981	1986	1991	1996
Lambton County	—	129,706	139,148	147,942	155,451
– Urban Areas	95,794	103,765	111,318	118,354	124,361
Essex County	—	326,256	342,032	356,420	368,199
– Urban Areas	282,162	296,893	311,249	324,342	335,061
Elgin/Middlesex Counties	—	387,428	400,210	409,812	415,723
– Urban Areas	336,429	368,057	380,200	389,321	394,937
Toronto Area(2)	—	3,359,991	3,516,601	3,643,949	3,737,712
– Urban Areas	3,005,450	3,191,991	3,340,771	3,461,752	3,550,826
Average Household Sizes(3)					
Lambton	3.17	2.94	2.80	2.70	2.70
Essex	3.10	2.90	2.77	2.70	2.70
Elgin/Middlesex	3.10	2.90	2.77	2.70	2.70
Toronto	3.10	2.90	2.80	2.70	2.70

(1) TEIGA, Demographic Bulletin, Oct. 1978
(2) Metropolitan Toronto, York, Peel, Durham, Halton
(3) Source: P. Barnard & Assoc., – data smoothed

EXHIBIT A–5
UNIT TYPE AS PERCENT OF NEW HOUSING REQUIREMENTS(1)

	1977–1981 %	1981–1986 %	1986–1991 %	1991–1996 %
Sarnia CA(2)				
– Single	64	69	84	88
– Semi-detached	3	3	3	2
– Row	4	3	3	2
– Apartments	29	25	10	8
Windsor CMA				
– Single	55	64	79	82
– Semi-detached	5	5	3	3
– Row	4	4	4	4
– Apartments	36	27	14	11
London CMA				
– Single	50	60	75	77
– Semi-detached	4	4	3	3
– Row	4	4	3	3
– Apartments	42	32	19	17
Toronto CMA				
– Single	41	44	48	55
– Semi-detached	12	13	13	12
– Row	5	5	4	4
– Apartments	42	38	35	29

(1) Source: P. Barnard and Assoc., Ontario Housing Requirements, 1976–2001, Exhibit 2.12
(2) Projections for Southwestern Ontario were used

crete and concrete products in terms of the Gross Provincial Product is:

$$C_t = 0.3\,P_t + 1.1(P_t - P_{t-4})$$

where

$C_t - 4$ = Concrete consumption in year t, in thousands of tonnes, excluding concrete used in roads

P_t = Gross Provincial Product in the year 4 years before t, in millions of constant 1971 $.

Concrete used for road construction was excluded from the analysis since road construction does not follow the changes of the Gross Provincial Product. The historical data for the production of concrete and concrete products and for the Gross Provincial Product are shown in Exhibit A-2. Exhibit A-3 shows the data of Exhibit A-2 in graphic form; it also shows the "prediction" of the forecasting equation described above had it been applied in earlier years. The diagrams provide an indication of the reliability of the model.

In order to use the equation for actual forecasting, the future growth of the Gross Provincial Product must be projected. Two economic scenarios were used for that purpose, as described in Section A.3.

A.5 FORECASTS OF RESIDENTIAL AND INDUSTRIAL LAND REQUIREMENTS AND RESIDENTIAL CONSTRUCTION

Forecasts of residential and industrial land requirements and of the numbers of new housing units were required in order to forecast the amount of mineral aggregates needed for the construction of residential buildings and subdivision roads.

The following methodology was applied:

1. Population forecasts were determined using projections prepared by the Ontario Ministry of Treasury, Economics and Intergovernmental Affairs, as shown in Exhibit A-4. The forecasts were prepared for a 20-year period, at 5-year intervals (1981, 1986, 1991 and 1996), from the base year of 1977.
2. Average household sizes were then forecast for the same 20-year period, as shown in Exhibit A-4, based on previous work for the Ontario Government.
3. A mix of housing unit types (single, semi-detached, row, and apartment) was forecast as a percentage of new housing re-

EXHIBIT A–7
URBAN RESIDENTIAL LAND REQUIREMENTS

(acres)

	1977–81	1981–86	1986–91	1991–96
Lambton	770	880	830	475
Essex	1600	1800	1650	865
Middlesex/ Elgin	1575	1520	1290	395
Toronto Area	13170	13660	9810	5060

EXHIBIT A–6
PROJECTED INCREASE IN HOUSING UNITS

	1977–81	1981–86	1986–91	1991–96
Lambton County				
Urban	4,294	4,642	4,159	2,270
Rural	1,036	1,160	1,040	576
Total	5,330	5,802	5,199	2,837
Essex County				
Urban	10,246	10,237	7,927	4,055
Rural	1,014	1,012	784	401
Total	11,260	11,249	8,711	4,456
Middlesex/Elgin Counties				
Urban	11,605	10,646	7,095	2,126
Rural	610	554	373	111
Total	12,215	11,200	7,468	2,237
Toronto Area				
Urban	98,587	105,165	70,600	33,915
Rural	5,189	5,535	3,715	1,785
Total	103,776	110,700	74,315	35,700

quirements, again using Ontario Government data as shown in Exhibit A-5.

4. The following densities were assumed for these housing unit types:

Single	:	4.5 units per gross acre
Semi-detached	:	7.0 units per gross acre
Row Housing	:	12.0 units per gross acre
Apartments:		
Toronto Area	:	35.0 units per gross acre
Other	:	27.0 units per gross acre

Using the above projections and assumptions, the numbers of new housing units and new residential land requirements were calculated for the four study areas, as shown in Exhibits A-6 and A-7.

New industrial land requirements were projected for the same areas and the same 20-year period, using labour force projections and an estimate of the total labour force per acre of developed industrial land. The latter estimates were based on past trends.

The total labour force divided by acres of industrial land was projected to decline in each demand area during the 1977-1996 period as follows:

Toronto area	:	48 declining to 43
London area	:	48 declining to 43
Windsor area	:	63 declining to 56

Since no data were available for the Sarnia area, the Sarnia-Lambton Area Planning Study projections were used.

The results of the industrial land requirement calculations are shown in Exhibit A-8.

A.6 FORECASTS OF ROAD CONSTRUCTION

The forecasts of mineral aggregates required for road construction were divided into three parts:

- provincial roads
- municipal roads
- subdivision roads.

In the first two parts, road construction expenditures were first forecast, and then multiplied by an "input factor". The "input factor", in this case, expressed the amount of mineral aggregates required for road construction in tonnes per dollar of construction expenditure.

In the case of subdivision roads, the acres of new developments were forecast and then multiplied by an "input factor" expressed in tonnes per acre.

A.6.1 Provincial Roads

A review of expenditures by the Ontario Ministry of Transportation and Communications (MTC), on provincial road construction *for the entire Province* from 1957 to 1977 was made using data obtained from the Ministry's annual reports.

This set of data was converted to 1977 dollars using the Statistics Canada Highway Price Index for Ontario. These data are shown in both tabular and graphic form in Exhibits A-9 and A-10. The total provincial road construction expenditures for 1978 to 1990 were then projected by continuing the past average trend of a 1.3% annual decline.

The breakdown of the total provincial road construction expenditures into *each demand area* for the years 1965 to 1977 inclusive was obtained from the MTC Financial Office. These data were also converted to 1977 dollars using the Statistics Canada Highway Price Index for Ontario, and are shown in Exhibit A-11.

The construction expenditures in each demand area as a percentage of the total provincial road construction expenditures are also given in Exhibit A-11. A review of the historical data indicates that in each demand area there are some years showing construction expenditures substantially higher than the "normal" or average level. These are, in all likelihood, periods in which there was a high level of construction of new highway links within the demand area.

For the purpose of forecasting construction expenditures in each demand area, 20-year historical data were derived into years of "high" construction activity and years of "normal" construction activity. The construction expenditures in each area were calcu-

EXHIBIT A–8
INDUSTRIAL LAND REQUIREMENTS

DEMAND AREA	DEVELOPED INDUSTRIAL LAND (acres)	PROJECTED INDUSTRIAL LAND REQUIREMENTS (acres)		
		1976–81	1976–86	1976–96
Toronto Area	32811	6000	12400	19900
Elgin/Middlesex	3255	1200	1600	2200
Essex	2000	800	1200	1700
Lambton	Not Available	Not Calculated		2100

lated as a percentage of the total provincial road construction expenditures for both the high and normal activity levels as follows:

	High Construction Activity	Normal Construction Activity
Toronto Demand Area	24.8%	18.2%
London Demand Area	3.5%	1.2%
Windsor Demand Area	3.3%	1.6%
Sarnia Demand Area	4.5%	0.7%

The projected total Provincial road construction expenditures were multiplied by the above percentages in each demand area to obtain a range of construction expenditures forecast for future years.

Discussions were also held with MTC officials who provided estimates of likely expenditures in the next 5 to 10 years in each demand area, based on their best judgment.

The final forecasts of provincial road construction expenditures in each demand area were prepared by reconciling the projected ranges derived from the percentage breakdown of the total provincial road expenditures with the estimates of the MTC.

The forecasts are shown in Exhibit A-11.

A.6.2 Municipal Roads

A review of road construction expenditures by each municipality in each demand area from 1958 to 1977 was conducted using MTC records. In total, the spending of 174 municipalities was examined.

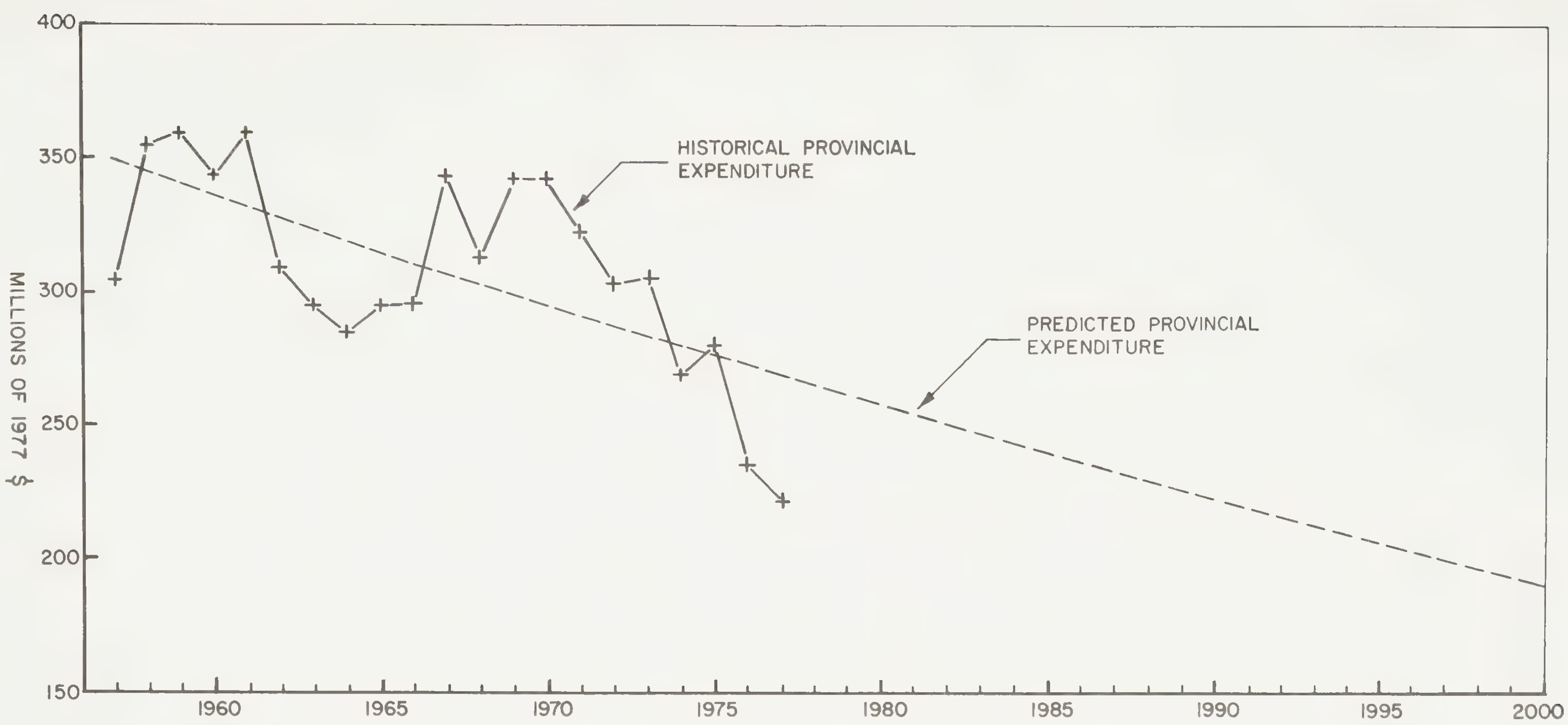
These road construction expenditures were converted to 1977 dollars using the Statistics Canada Highway Price Index for Ontario; they were summarized in Exhibit A-12.

EXHIBIT A–9
MTC[2] PROVINCIAL ROAD CONSTRUCTION EXPENDITURES

YEAR	CONSTRUCTION EXPENDITURE[1] (millions of current $)	ONTARIO HIGHWAY PRICE INDEX	CONSTRUCTION EXPENDITURE[1] (millions of 1977 constant $)
1957	116	71.4	$304
1958	126	66.4	355
1959	133	69.2	360
1960	120	65.2	344
1961	117	60.8	359
1962	111	67.0	308
1963	121	76.9	294
1964	115	75.2	285
1965	138	87.5	296
1966	152	95.7	296
1967	175	95.0	343
1968	155	92.1	315
1969	172	93.6	342
1970	178	96.8	343
1971	172	100.0	322
1972	172	106.3	303
1973	187	114.5	305
1974	215	149.5	269
1975	247	164.4	281
1976	218	172.4	236
1977	221	186.7	221
Forecast			
1980			260
1985			243
1990			228
1995			213
2000			190

[1] The above figures include construction expenditures on King's Highways, secondary highways, tertiary roads, access and industrial roads, and expressways. Ferries, airstrips, development roads, and connecting links are not included.

[2] Ministry of Transportation and Communications.



CONSTRUCTION EXPENDITURES - ONTARIO

Provincial Roads - Ministry of Transportation and Communications

A-10

Available Roads Need Studies were used as a basis for forecasting future expenditures on all municipal road construction. These studies were available for all counties, regions, and 34 lower-tier municipalities within the four demand areas as follows:

- Toronto area: 34 Roads Need Studies were available, representing 99% of the area's total historical construction expenditures over the past 10 years,
- London area: 5 Studies were available, representing 76% of the area's total historical construction expenditures over the past 10 years,
- Windsor area: 2 Studies were available, representing 74% of the area's total historical construction expenditures over the past 10 years.
- Sarnia area: 3 Studies were available, representing 52% of the area's total historical construction expenditures over the past 10 years.

A listing of projected road construction expenditures for each municipality that had a Roads Need Study was obtained for the next five years from the Ministry of Transportation and Communications. The projected expenditures for each demand area were then determined for 1980-1984 by factoring the totals from the Roads Need Studies in proportion to the historical percentage of road construction expenditures represented by the available Need Studies. These demand area projections are shown in Exhibit A-12. It was the opinion of the Ministry of Transportation and Communications that the level of funding (and spending) in both the 5- and 10- year periods will remain relatively constant in constant dollars.

MTC's present policy on municipal subsidies is to provide funds on the basis that a municipality's road system will stay at the present level of service (i.e., the value of backlog deficiencies will not be reduced). This implies that municipalities will be funded in the future by MTC at the same rate as they are today. This is significant in forecasting future expenditures since the historical expenditure patterns can be used to forecast future road construction spending. The final forecasts were therefore taken as the mean of the Roads Need expenditure projections and the historical average construction expenditures for each demand area. It was assumed that this forecast will be valid for the next 20 years. The forecasts are summarized in Exhibit A-12.

A.6.3 Subdivision Roads

The forecasts of mineral aggregates required for subdivision roads were determined per acre of new subdivision development, rather than per dollar of road con-

EXHIBIT A–11
MTC[1] ROAD CONSTUCTION EXPENDITURES IN DEMAND AREAS

(thousands of 1977 constant $)

YEAR	TORONTO DEMAND AREA	LONDON DEMAND AREA	WINDSOR DEMAND AREA	SARNIA DEMAND AREA	TOTAL	PROVINCIAL TOTAL
1965	58,209 (19.6)	5,388 (1.8)	7,249 (2.4)	3,730 (1.2)	74,576 (25.2)	295,726
1966	60,319 (20.3)	4,257 (1.4)	5,553 (1.8)	876 (0.3)	71,005 (23.9)	296,137
1967	66,319 (19.3)	5,240 (1.5)	2,460 (0.7)	3,219 (0.9)	77,438 (22.5)	343,233
1968	75,333 (23.9)	4,799 (1.5)	3,156 (1.0)	1,672 (0.5)	84,960 (26.9)	315,207
1969	86,523 (25.2)	3,690 (1.0)	4,054 (1.1)	2,496 (0.7)	96,763 (28.2)	342,373
1970	82,580 (24.0)	1,898 (0.5)	2,423 (0.7)	2,373 (0.7)	89,274 (25.9)	343,914
1971	83,871 (26.0)	675 (0.2)	2,563 (0.8)	1,307 (0.4)	88,516 (27.4)	322,166
1972	45,826 (15.1)	4,008 (1.3)	9,793 (3.2)	2,590 (0.8)	62,217 (20.5)	303,039
1973	55,150 (18.0)	3,634 (1.1)	9,984 (3.2)	6,026 (1.9)	74,794 (24.5)	305,164
1974	67,242 (24.9)	3,017 (1.1)	5,862 (2.1)	8,727 (3.2)	84,848 (31.5)	269,235
1975	45,138 (16.0)	2,270 (0.8)	4,716 (1.6)	17,398 (6.2)	69,522 (24.7)	280,704
1976	31,702 (13.4)	4,294 (1.8)	6,840 (2.9)	16,278 (6.9)	59,114 (25.7)	235,814
1977	37,524 (16.9)	7,757 (3.5)	5,042 (2.2)	11,772 (5.3)	62,095 (28.0)	221,095
Forecast						
1980	61,000 (23.5)	11,300 (4.3)	9,200 (3.5)	3,600 (1.4)	85,100 (32.7)	260,000
1985	44,500 (18.3)	3,200 (1.3)	3,600 (1.5)	3,600 (1.5)	54,900 (22.6)	243,000
1990	44,500 (19.5)	3,200 (1.4)	3,600 (1.6)	3,600 (1.6)	54,900 (24.1)	228,000
1995	44,500 (20.9)	3,200 (1.5)	3,600 (1.7)	3,600 (1.7)	54,900 (25.8)	213,000
2000	44,500 (22.2)	3,200 (1.6)	3,600 (1.8)	3,600 (1.8)	54,900 (27.5)	200,000

NOTE: Figures in parentheses are percentages of construction expenditure as a percentage of the total Provincial construction expenditure.
(1) Ministry of Transportation & Communications.

struction expenditure. Hence, it was necessary to first forecast future subdivision acreages in each demand area. These forecasts were described in Section A.5.

Subdivision road standards were obtained from the larger municipalities within the four demand areas, as well as data on pavement cross-sections currently being used in the same areas. Aggregate quantities needed per unit length of roads and roadway elements were then calculated, including curbs and gutters, but excluding sidewalks, water mains, sanitary and storm sewers, and other utilities.

A total of 20 residential and industrial subdivisions were sampled from the four demand areas to obtain the length of road per acre of development. Although the type and length of road per acre can vary widely for different developments, the following average values were used in determining the input factors for subdivision road construction:

- residential subdivisions : 43 metres of road/acre
- industrial subdivisions : 17 metres of road/acre.

These values were used in all four demand areas and are believed to be representative of current subdivision developments within each area.

EXHIBIT A–12
MUNICIPAL ROAD CONSTRUCTION EXPENDITURES IN DEMAND AREAS

(thousands of 1977 constant $)

YEAR	TORONTO	LONDON	WINDSOR	SARNIA
1958	70,600	10,100	6,700	4,100
1959	85,600	9,100	2,900	5,400
1960	112,200	12,000	6,300	5,400
1961	131,000	8,700	6,400	6,100
1962	122,600	9,900	7,900	7,500
1963	139,100	8,700	6,500	5,100
1964	131,900	12,300	7,900	4,800
1965	112,500	11,500	5,800	6,000
1966	114,900	11,400	5,500	6,800
1967	130,200	12,000	6,300	6,400
1968	144,600	12,500	7,300	6,500
1969	154,000	10,400	7,700	8,100
1970	137,600	10,700	11,400	8,400
1971	141,300	12,500	13,200	7,400
1972	136,500	11,400	8,200	6,000
1973	127,300	13,600	8,600	6,000
1974	113,800	13,800	8,400	4,200
1975	103,900	12,700	9,300	4,600
1976	92,100	11,800	7,300	4,800
1977	91,300	14,600	6,900	4,200
Forecast after 1980	119,100	14,700	6,450	4,750

EXHIBIT A–13
CONSTRUCTION CATEGORIES INCLUDED IN MINERAL AGGREGATE INPUT ANALYSIS

	LINE IN STATISTICS CANADA PUBLICATION #64-201	
	After 1972	1972 and Before
Non-Residential Building		
Industrial	8	pre-2
Commercial	13	pre-6
Institutional	22	pre-14
Other	27	pre-18
Non-Road Engineering		
Marine structures	37	pre-25
(–less dredging)	(–41)	(–28)
Sidewalks	48	36
Airfields	49	37
Storm sewers	51	38
Water services	52	39
Sewage systems	53	40
Dams	56	pre-43
Railway roadbeds	65	49
Gas services	69	52

Forecasts for residential and industrial land requirements and for residential construction in new subdivision areas were developed on the basis of demographic projections, as described in Section A.5.

A.7 FORECASTS OF NON-RESIDENTIAL BUILDING CONSTRUCTION, NON-ROAD ENGINEERING CONSTRUCTION AND OTHER AGGREGATE-CONSUMING ACTIVITIES

After having completed the forecasts of road construction expenditures and of residential construction in terms of housing units and land areas, forecasts had to be prepared for the remaining aggregate-consuming categories. These are:

- non-residential building construction
- non-road engineering construction
- other aggregate-consuming activities.

A forecasting model was therefore developed for construction expenditures on non-residential building and non-road engineering construction in Ontario. These relate to the first two activity groups. The third group consumes relatively small amounts of aggregates and was therefore not forecast separately but assumed to vary in proportion with the first two groups.

Since data was not available for the individual demand areas, the consumption of mineral aggregates

for these purposes had to be forecast first for the Province as a whole and subsequently broken down into the individual demand areas.

The expenditure forecasts were derived by fitting linear equations to historical data on new construction expenditures in Ontario for a 21-year period, 1957-1977 inclusive. The data was obtained from Statistics Canada publication #64-201.

All expenditures were converted to a common base (1971 dollars) through the Non-residential Construction Price Index published by Statistics Canada (#64-007).

Only construction categories that consumed significant amounts of mineral aggregates were included in the analysis. These are listed in Exhibit A-13. The construction categories that were excluded were assumed to consume relatively small amounts of aggregates in relation to the total construction value.

It was found that the best estimates of aggregate consumption per construction value can be obtained by combining *all* the selected non-residential building and non-road engineering construction data, both for the purpose of historical analysis and for forecasting future trends.

Many types of relations were tested between the construction values and the Gross Provincial Product. The best "fit" of historical data to a linear equation was found by using the following equation:

$$(B_t + E_t) = 700 + 0.016\,P_t + 0.085(P_{t-1} - P_{t-4})$$

where

B_t is the value of non-residential building construction in Ontario in millions of constant (1971) dollars in year t

EXHIBIT A–14
HISTORICAL CONSTRUCTION EXPENDITURES AND GROSS PROVINCIAL PRODUCT

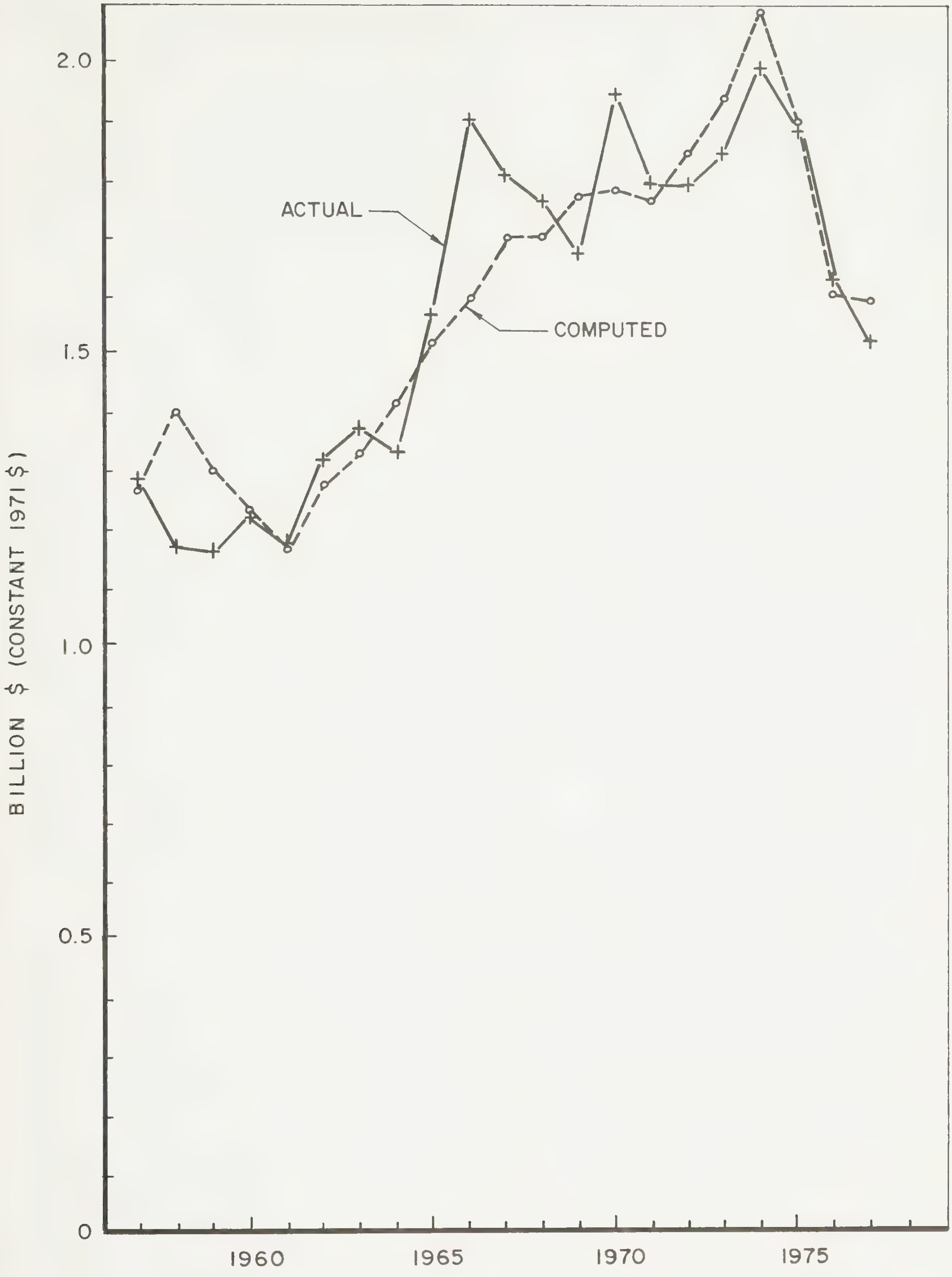
	CONSTRUCTION EXPENDITURES[1]			GROSS PROVINCIAL PRODUCT	
	Actuals in Current Dollars (million $)	Actual in 1971 Dollars (million $)	Computed in 1971 Dollars using model[2] (million $)	Current Dollars[3] (million $)	1971 Dollars[4]
1957	867.3	1283.0	1263.6		21,056
1958	785.2	1166.7	1401.5		21,004
1959	784.5	1158.8	1294.9		21,677
1960	823.9	1206.3	1223.8		22,186
1961	801.9	1177.5	1161.4		23,224
1962	901.6	1318.1	1271.7	17,838	24,302
1963	962.8	1369.6	1325.0	19,054	25,473
1964	957.9	1326.7	1410.7	20,912	27,300
1965	1193.7	1566.5	1505.3	22,944	29,006
1966	1535.0	1899.8	1592.6	25,696	31,109
1967	1515.6	1802.1	1694.2	27,911	32,492
1968	1488.0	1752.6	1691.5	30,771	34,691
1969	1490.4	1663.4	1767.0	34,061	36,783
1970	1832.8	1945.6	1776.0	36,282	37,404
1971	1792.4	1792.4	1752.5	40,000	40,000
1972	1894.3	1792.1	1832.4	44,982	42,881
1973	2093.3	1831.4	1937.2	51,822	45,220
1974	2648.5	1989.9	2090.0	60,705	45,609
1975	2805.2	1878.9	1888.0	66,601	44,759
1976	2654.1	1624.3	1599.4	76,137	46,624
1977	2704.0	1519.1	1586.4	84,651	48,344

(1) On all construction categories shown in Exhibit A-13.

(2) Computed by computer. Small deviations from hand computations are due to rounding.

(3) First available year as calculated by Statistics Canada is 1962.

(4) For1962–1977, current dollar values from Statistics Canada are deflated by the implicit GNP price index. For 1957–1961, constant dollar GPP's from the Ontario Economic Review were adjusted by the ratio of the estimates of the Ontario GPP for 1962 and the corresponding Ontario Economic Review figure (to make the series consistent).



CONSTRUCTION EXPENDITURES - ONTARIO

Categories of Exhibit A-13

A-15

E_t is the value of selected non-road engineering construction in Ontario in millions of constant (1971) dollars in year t

P_t is the Gross Provincial Product of Ontario in millions of constant (1971) dollars in year t

P_{t-1}, P_{t-4} same as above, one or four years before the year above.

The values of the Gross Provincial Product in current and constant terms are shown in Exhibit A-14. In addition, the actual construction expenditures are shown, as well as those computed by the above equation, both in current and constant dollars.

The "fit" of the equation can be assessed by comparing the values predicted by the equation and the actual construction values in constant dollars. These two series are shown graphically in Exhibit A-15.

A.8 FORECASTS OF MINERAL AGGREGATE INPUT FACTORS

The input factor used for concrete production was simple: 1.05 tonnes of aggregates per one tonne of concrete (to account for losses in the manufacturing of cement and concrete).

The input factor for residential building construction was defined as tonnes of aggregates per housing unit.

The input factors for provincial and municipal road construction, and for other uses (non-residential building construction, non-road engineering construction and other activities) were defined as tonnes of aggregates per dollar of expenditure.

For concrete production and road construction, the input factors were determined through direct analysis. For the other categories the input factors were determined through statistical analysis (linear regression) of past data.

The input factors for subdivision road construction were defined as tonnes of aggregates per acre of development.

A.8.1 Provincial Road Construction Input Factors

The amount of mineral aggregates per dollar of construction expenditure (i.e., the input factors) for provincial highways in Ontario as a whole and in the demand areas are shown in Exhibits A-16 and A-17. These indicate substantial but irregular variations in the input factors from year to year, as well as from one district to

EXHIBIT A–16
PROVINCIAL HIGHWAY CONSTRUCTION INPUT FACTORS FOR ONTARIO

YEAR	CONSTRUCTION EXPENDITURE (million $)[1]	AGGREGATE CONSUMPTION (million tonnes)	INPUT FACTOR (tonnes/1000 $)[1]
1977	221.1	18.01	81.5
1976	236.0	14.43	61.1
1975	281.0	13.63	48.5
1974	269.2	14.42	53.5
1973	305.2	15.17	49.7
Total	$1,312.5	75.66	57.6

Input Factor for 5-year Period = 57.6 tonnes/1000 $

[1] Constant (1977) dollars

EXHIBIT A–17
PROVINCIAL HIGHWAY CONSTRUCTION INPUT FACTORS FOR MTC TORONTO, LONDON AND CHATHAM DISTRICTS

	TORONTO DISTRICT (Toronto Demand Area)			LONDON DISTRICT (London Demand Area)			CHATHAM DISTRICT (Windsor and Sarnia Demand Areas)		
	Construction Expenditure (million $)[1]	Aggregate Consumption (million tonnes)	Input Factor (tonnes/1000 $)[1]	Construction Expenditure (million $)[1]	Aggregate Consumption (million tonnes)[1]	Input Factor (tonnes/1000 $)	Construction Expenditure (million $)[1]	Aggregate Consumption (million tonnes)[1]	Input Factor (tonnes/1000 $)
1977	39.3	1.79	45.5	11.0	0.51	46.4	19.8	0.81	40.9
1976	29.9	1.00	33.4	6.1	0.57	93.4	22.8	0.74	32.4
1975	44.1	2.20	49.9	5.9	0.33	55.9	21.4	0.70	32.7
1974	45.5	1.42	31.2	7.7	0.67	87.0	15.1	0.40	26.5
1973	49.3	1.93	39.1	6.1	0.23	37.7	15.5	1.02	65.8
	208.1	8.34	40.0	36.9	2.31	62.6	94.6	3.67	38.8

[1] Constant (1977) dollars

EXHIBIT A–18
MUNICIPAL ROAD CONSTRUCTION INPUT FACTORS

DEMAND AREA	CONTRACTS ANALYZED		
	Construction Expenditure (million $)[1]	Aggregate Consumption (million tonnes)	Input Factor (tonnes/ 1000 $)[1]
Toronto	62.8	4.67	74.3
London	19.5	1.27	65.1
Windsor	8.5	0.43	50.0
Sarnia	5.6	0.34	60.7

[1] Constant (1977) dollars

the other. The assumption can be made that the average input factor of 5 years provides an adequate estimate of future input factors to be used in the long-term forecasts.

Exhibits A-16 and A-17 also indicate that the average input factor in the MTC District of London corresponds broadly to the provincial average, but in the MTC Districts of Toronto and Chatham, the average input factors are approximately 30% below the provincial average. The MTC Districts correspond approximately to the demand areas defined in this study (the District of Chatham including both the Windsor and the Sarnia areas).

In order to forecast the mineral aggregate consumption for Provincial highways, the forecast expenditures were multiplied by the input factors, as summarized in Section A.9.

A.8.2 Municipal Road Construction Input Factors

The mineral aggregate input factors in terms of tonnes per dollar of construction expenditure on municipal roads were derived by analyzing approximately 210 construction contracts in the four demand areas from 1975 to 1978 inclusive. All expenditures were converted to 1977 constant dollars using the Statistics Canada Highway Price Index for Ontario.

Exhibit A-18 shows the results of this analysis. It indicates the highest input factor for the Toronto area and the lowest input factor for the Windsor area.

In order to forecast the mineral aggregate consumption for municipal roads, the forecast expenditures were multiplied by the input factors as summarized in Section A.9.

A.8.3 Subdivision Road Construction Input Factors

Input factors for subdivision roads were developed by sampling actual engineering designs of 20 subdivisions. The factors are shown in Exhibit A-19. The factors are expressed in tonnes of mineral aggregates per acre.

A.8.4 Input Factors For Non-Residential Building, Non-Road Engineering Construction and Other Activities

Historical volumes of mineral aggregates produced and consumed in the Province of Ontario, including sand, gravel, crushed stone, cement and lime are reported in Statistics Canada publication 26-202. These reported volumes were increased by 16% to account for data deficiencies identified by the Ontario Ministry of Natural Resources. Aggregates imported to Ontario were added and aggregates exported were subtracted from the numbers, based on Statistics Canada Shipping Reports.

Since the production of concrete and concrete products were forecast separately, the amounts of mineral aggregates used for concrete were subtracted from the total volumes of mineral aggregates used in Ontario. Furthermore, since the mineral aggregates used for road construction were forecast directly, these amounts were also subtracted.

After substantial experimentation with various groupings of variables, the following equation was found to provide the best "fit" between mineral aggregate consumption and construction expenditures:

$$A—C-0.13\,R=0.15\times H+0.03\times(B+E)$$

where:

- A = Total aggregate volume, (million tonnes)
- C = Aggregate used for concrete, (million tonnes)
- R = Road construction expenditure, (million $)
- H = Housing starts, (in 000)
- B = Non-residential building construction expenditure, (million $)
- E = Non-road engineering construction expenditure in selected categories, (million $)
- 0.13 = Average road construction input factor in tonnes/$
- 0.15 = Residential building construction input factor in tonnes/1000 housing starts
- 0.03 = Non-residential building and non-road engineering construction input factor in tonnes/ $

All expenditures are in constant 1971 dollars, using the price indexes defined earlier.

EXHIBIT A–19
NEW SUBDIVISION ROAD CONSTRUCTION INPUT FACTORS

Demand Area	INPUT FACTOR (tonnes/acre) Residential Subdivisions	Industrial Subdivisions
Toronto	430	300
London	470	250
Windsor	380	160
Sarnia	310	270

The input factor of 0.13 tonnes per dollar for roads was derived from the input factors shown in Exhibits A-16 to A-19 and the appropriate blend of Provincial highways (35%) and municipal/subdivision roads (65%). It should be noted that the expenditures in the equation above were expressed in 1971 constant dollars, whereas the direct input factors for roads were expressed in 1977 constant dollars. The inflation index from 1971 to 1977 was 1.867. Thus in terms of 1977 dollars, the road input factor would be 0.07 tonnes per dollar.

The input factors listed above indicate that a broad average amount of mineral aggregates used per new housing unit can be estimated as 150 tonnes, excluding concrete. It is estimated that approximately 50 tonnes were used for the housing units themselves and 100 tonnes for associated services that can be directly related to the construction of the units at the time they were built.

It is estimated that in addition to these amounts, an additional 80 tonnes in concrete is used per unit. This amount is included in the total forecasts for concrete.

The equation also indicates that the average input factor for all other construction (in the categories shown in Exhibit A-13) is 0.03 tonnes per dollar of construction expenditure if the expenditure is expressed in 1971 constant dollars. This corresponds to an input factor of 0.016 tonnes per dollar if the expenditure is expressed in 1977 dollars.

The factors above include small amounts of aggregates that are used for purposes other than construction. They were nevertheless related to construction expenditures for lack of more specific factors and considering the small amounts involved.

A.9 FORECASTS OF TOTAL MINERAL AGGREGATE DEMAND FOR TWO ECONOMIC PROJECTIONS

The forecasts of the total demand for mineral aggregates in the four demand areas and in Ontario as a whole were prepared using the methodologies and data described in the preceding Sections. Forecasts were prepared for each of the four usage groups as follows:

1. *Concrete and concrete products.* The forecasting model described in Section A.4 was used to forecast the future consumption of concrete and concrete products. Since, according to the model, the factor that determines concrete consumption is the Gross Provincial Product, the projections of that factor, made in Section A.3 were used. The resulting forecasts of the demand for concrete, prepared for the whole of Ontario are shown in Exhibits A-20 and A-21.

   The 1977 consumption of concrete and concrete products in each demand area, as a percentage of total Ontario consumption, was estimated by reconciling market data obtained from industry with published construction surveys for the regions, counties, and major municipalities in Ontario.
2. *Residential building construction.* The mineral aggregate demand for residential building construction was forecast using the projected increase in the number of housing units shown in Exhibit A-6 and multiplying the estimated annual increase in housing units by the input factor of 150 tonnes per unit, in accordance with the model described in Section A.9. These forecasts exclude the demand for concrete which has already been accounted for in the first usage group.

   The same method was used to estimate the 1977 consumption.
3. *Road construction.* In developing the expenditure forecasts for road construction, the projected construction expenditures (Section A.6) were multiplied by the appropriate input factors (Section A.8) in order to translate dollars into tonnes of mineral aggregates.

   The consolidated road forecasts for each demand area were derived from the following Sections:

	Expenditures	Input Factor
Provincial Highways	A.6.1	A.8.1
Municipal Roads	A.6.2	A.8.2
Subdivision Roads	A.5 A.6.3	A.8.3

   An estimate of the mineral aggregate requirements for road construction for the whole of *Ontario* was obtained by calculating the combined growth rate of the aggregate demand for road construction in the Toronto, London, Windsor and Sarnia demand areas, and applying that growth rate to the estimated 1977 volume of aggregates used in Ontario's road construction sector.*
4. *Other Uses.* The major categories in this "residual" usage group are non-residential building construction and non-road engineering construction. The growth rate of this group was projected using the model for expenditures described in Section A.7 and the average input factor of 0.03 tonnes/dollar shown in Section A.8.

   The growth factors are shown in Exhibits A-20 and A-21 for the two economic projections. Before breaking down the forecasts into the four study areas the 1977 total mineral aggregate consumption was determined for

* *By applying the average overall input factor of 0.07 tonnes per dollar of expenditure to the 1977 total road construction expenditures in Ontario.*

each area using the production statistics of the Ministry of Natural Resources and the results of a special survey described in Chapter 4. These amounts were adjusted by the ratio of the total 1977 Ontario aggregate consumption estimated by the models to the actual consumption in order to eliminate any deviation from the "normal" demand that might have been particular to 1977 but should not be part of the forecasting base. The amounts of aggregate used for concrete, road construction, and residential building construction, determined earlier for 1977, were then subtracted from the totals to obtain the "residual" amounts for each demand area. The Ontario growth rate projections shown in Exhibits A-20 and A-21 were then applied to the 1977 "residual" volumes of each area to project the corresponding future volumes.

The results of all the forecasts corresponding to Projections I are summarized for each demand area and for Ontario in Exhibits 3-1 to 3-9 of Chapter 3 of the Report. The corresponding forecasts for Projection II are summarized in Exhibits 3-11 to 3-15 of Chapter 3 of the Report.

EXHIBIT A–20
FORECASTS OF AGGREGATE DEMAND: CONTINUING GROWTH ASSUMPTION

YEAR	% GROWTH RATES(1) GNP	GPP	ONTARIO GPP[1]	DEMAND FOR CONCRETE		VALUE OF "OTHER" CONSTRUCTION	
	%	%	million $	million tonnes(2)	Growth from 1977	million $ (1), (3)	Growth from 1977
1971			40100				
1972	6.14	6.94	42881				
1973	7.54	5.45	45220				
1974	3.53	0.86	45609				
1975	1.36–	1.86	44759				
1976	5.53	4.17	46624				
1977	2.65	3.69	48344	18.0	1.0	1592.8	1.0
1978	3.36	2.03	49326				
1979	3.35	2.10	50360				
1980	3.35	2.20	51470	20.7	1.153	1841.1	1.156
1981	3.35	2.31	52660				
1982	3.35	2.41	53930				
1983	3.35	2.52	55290				
1984	3.35	2.62	56730				
1985	3.35	2.73	58280	23.6	1.313	1978.4	1.242
1986	3.35	2.83	59930				
1987	3.35	2.94	61700				
1988	3.35	3.04	63570				
1989	3.35	3.15	65570				
1990	3.35	3.25	67700	28.8	1.597	2262.8	1.421
1991	3.35	3.35	69970				
1992	3.35	3.35	72314				
1993	3.35	3.35	74736				
1994	3.35	3.35	77240				
1995	3.35	3.35	79828	34.7	1.924	2595.2	1.630
1996	3.35	3.35	82502				
1997	3.35	3.35	85266				
1998	3.35	3.35	88122				
1999	3.35	3.35	91074				
2000	3.35	3.35	94125	41.0	2.268	2934.6	1.843

(1) Constant (1971) $
(2) Per equation, Section A.4
(3) Per equation, Section A.7 (Input factor: 0.03 tonnes/$)

EXHIBIT A–21
FORECASTS OF AGGREGATE DEMAND: SLOW GROWTH ASSUMPTION

YEAR	% GROWTH RATES(1) GNP	GPP	ONTARIO GPP[1]	DEMAND FOR CONCRETE		VALUE OF "OTHER" CONSTRUCTION	
	%	%	million $	million tonnes(2)	Growth from 1977	million $ (1), (3)	Growth from 1977
1971			40100				
1972	6.14	6.94	42881				
1973	7.54	5.45	45220				
1974	3.53	0.86	45609				
1975	1.36–	1.86	44759				
1976	5.53	4.17	46624				
1977	2.65	3.69	48344	18.0	1.0	1593	1.0
1978	3.36	2.03	49326				
1979	3.35	1.75	50189				
1980	3.35	1.75	51067	20.2	1.123	1761	1.106
1981	3.35	1.75	51961				
1982	3.35	1.75	52870				
1983	3.35	1.75	53795				
1984	3.35	1.75	54736				
1985	3.35	1.75	55694	20.9	1.158	1825	1.146
1986	3.35	1.75	56669				
1987	3.35	1.75	57661				
1988	3.35	1.75	58670				
1989	3.35	1.75	59697				
1990	3.35	1.75	60742	22.3	1.237	1927	1.210
1991	3.35	1.75	61805				
1992	3.35	1.75	62886				
1993	3.35	1.75	63987				
1994	3.35	1.75	65107				
1995	3.35	1.75	66246	24.8	1.378	2038	1.280
1996	3.35	1.75	67405				
1997	3.35	1.75	68585				
1998	3.35	1.75	69785				
1999	3.35	1.75	71006				
2000	3.35	1.75	72249	27.0	1.503	2159	1.355

(1) Constant (1971) $
(2) Per equation, Section A.4
(3) Per equation, Section A.7 (Input factor: 0.03 tonnes/$)

APPENDIX B
Metric Units

1 kilometre (km)	=	0.6214 mile
1 metre (m)	=	3.2808 feet
1 millimetre (mm)	=	0.0397 inch
1 hectare (ha)	=	2.471 acres
1 litre (1)	=	0.220 gallon (imperial)
	=	0.00629 barrel
1 kilogram (kg)	=	2.2046 lbs.
1 metric tonne (t)	=	1.1023 short ton
	=	2204.6 lbs.

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